CHIPS P-1051

CHerenkov detectors In mine PitS

Physics soon and Physics later

R&D 3-5 year program

δ_{ChiPs}

The Bright Shining Physics Future

- Neutrinos are the only evidence for non-Standard Model physics
  - Higgs is where it should be
- Neutrinos are presently still mysterious
  - Are they Majorana or Dirac?
  - Are there only 3 or are there steriles?
  - Which one is the heaviest?
- Neutrinos hold out our last hope to explain the matter-antimatter asymmetry of the universe via neutrino CP violation
  - Not a small question to answer!
- A new window of opportunity has opened to search for neutrino δ_{CP} NOW!
  - Previous detector design focused on measuring tiny θ_{13}
  - Now detector design has advantage of known signal size (& background rejection level)

The Bright Shining Physics Future

- FNAL will have the best neutrino oscillation beam for the coming 30 years
  - NuMI now and LBNE later

BUT!

- **WE NEED BIGGER DETECTORS** to fully exploit the $500M investment
  - Maybe factor 2 from beam power in the future
  - These measurements will be **statistics limited** for a very very long time
- **WE NEED CHEAPER DETECTORS** because our physics is presently **limited by money**
  - CHIPS combines the idea of a cheaper design and a very large detector mass

AND!

- Combination of precision (LAr on-axis) and statistics (WC off-axis) at LBNE puts reach of even LAr-10 LBNE program close to NF predictions **if built upon full NuMI exploitation**

- CHIPS could cement FNAL's position to be first to measure δ_{CP}.

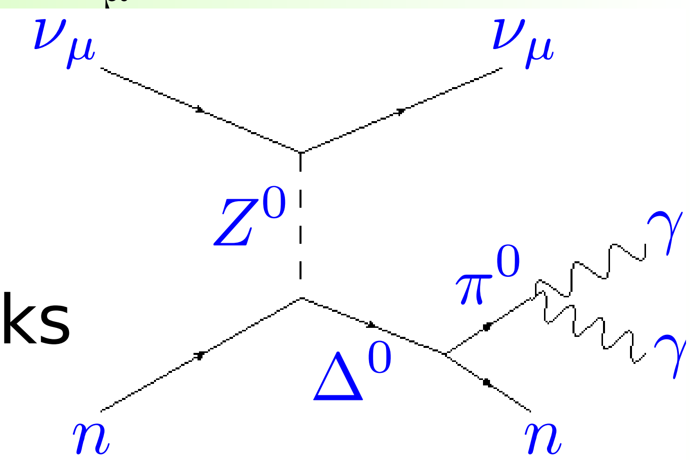
Orientation

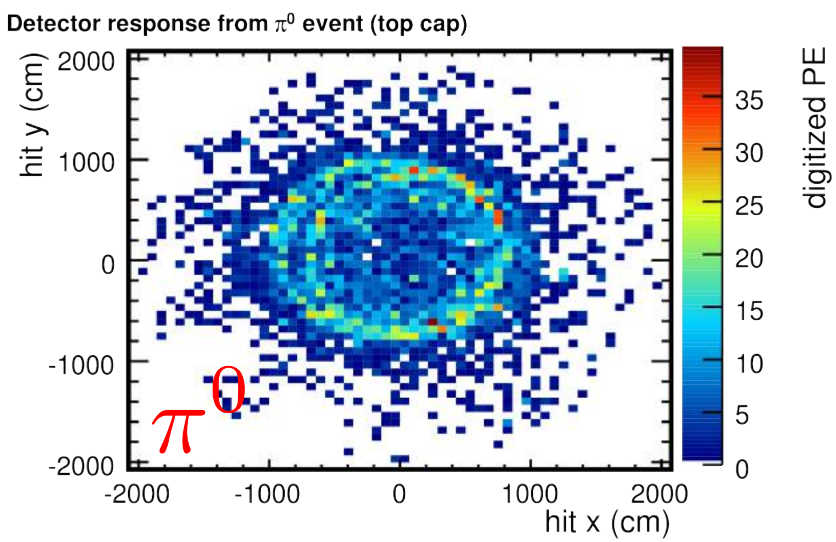
- The CHIPS physics goal is to **constrain or measure δ_{CP}** using NuMI neutrinos now and LBNE neutrinos later
- CHIPS is a water Cherenkov detector which will be sunk in a flooded mine pit in the path of the NuMI beam : water will provide mechanical support
- Its main development goal is to chart a new path towards cost effective Megaton neutrino detectors, hoping to get to $200k/kt (presently $1M/kt)
- It will complement NOVA (being more on-axis) and LBNE (more off-axis) when redeployed in the LBNE beam
- It will comprise a series of prototypes which will deliver physics results and demonstrate real costs for (O)100kt

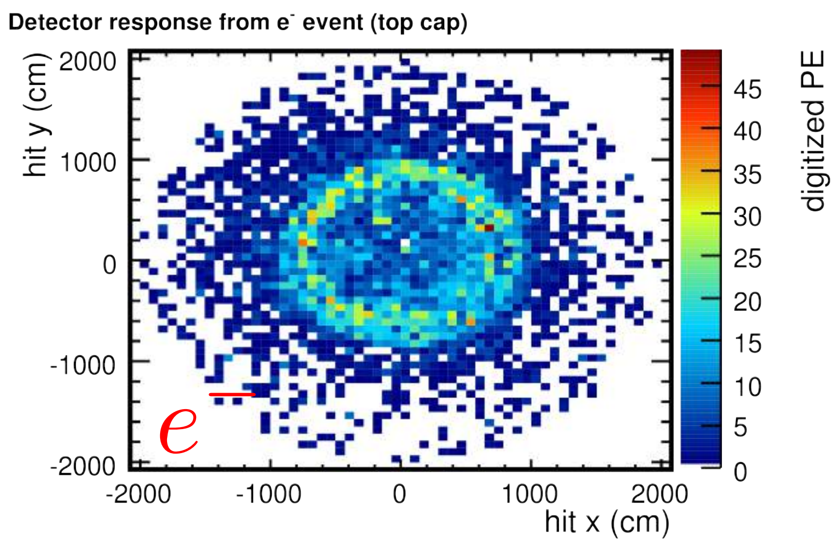
Orientation II

- The challenge is to find ν_e produced from the NuMI ν_μ beam and reject NC background
- Then compare ν_e in ν_μ beam with $\bar{\nu}_e$ in $\bar{\nu}_\mu$ beam

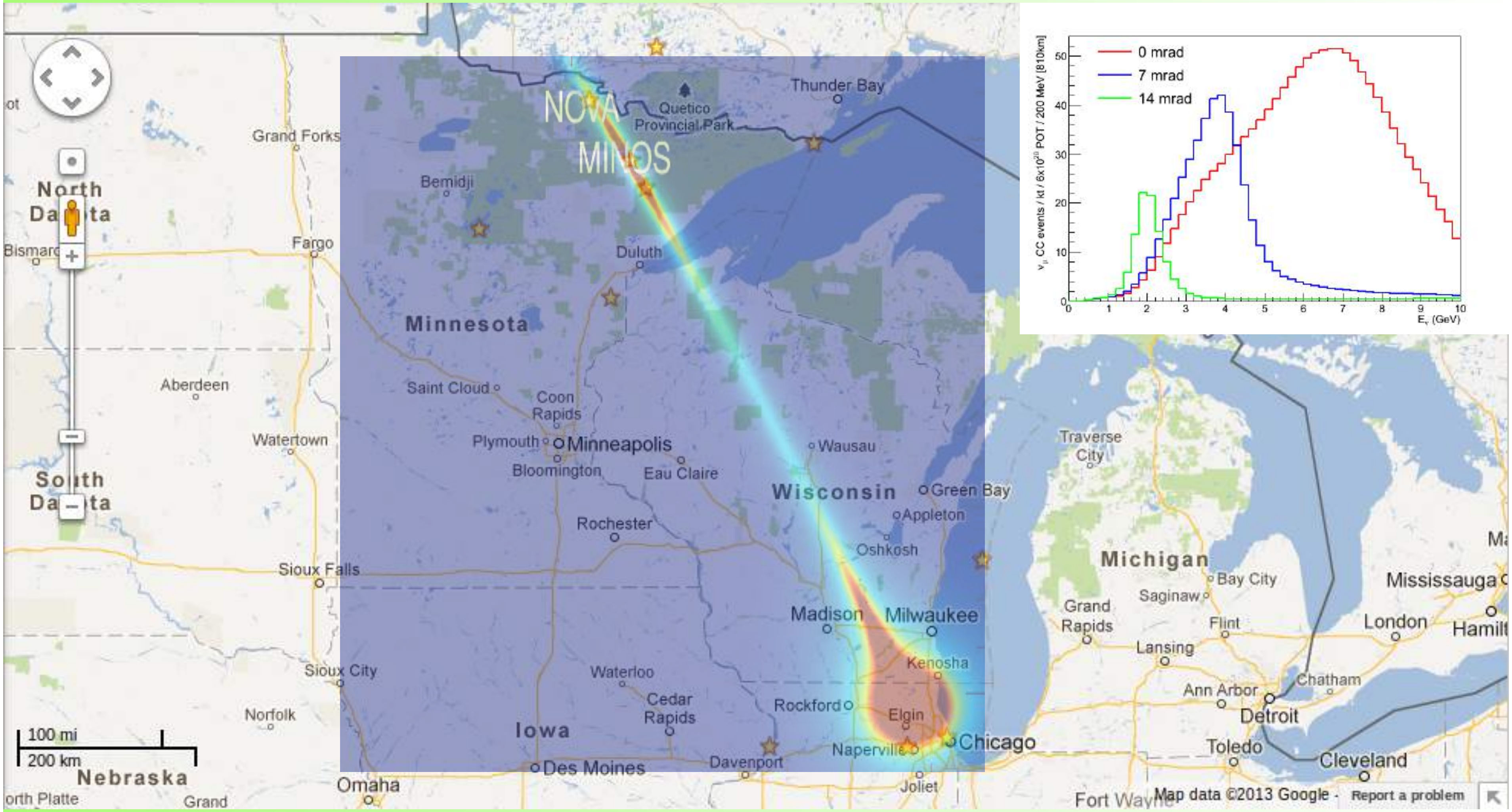
- Main background to ν_e CC appearance is ν_μ NC $\pi^0 \rightarrow \gamma\gamma$
- Need to distinguish multiple tracks from a single e^- track





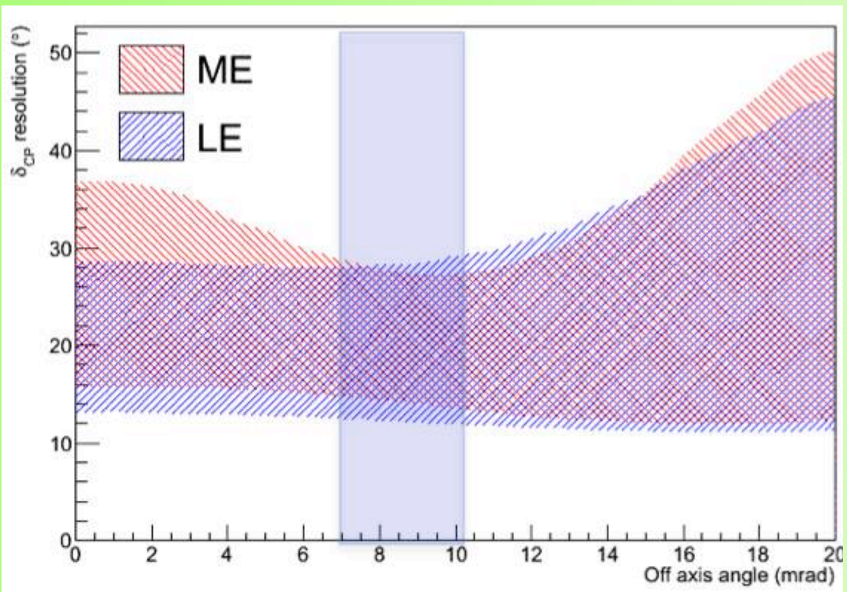


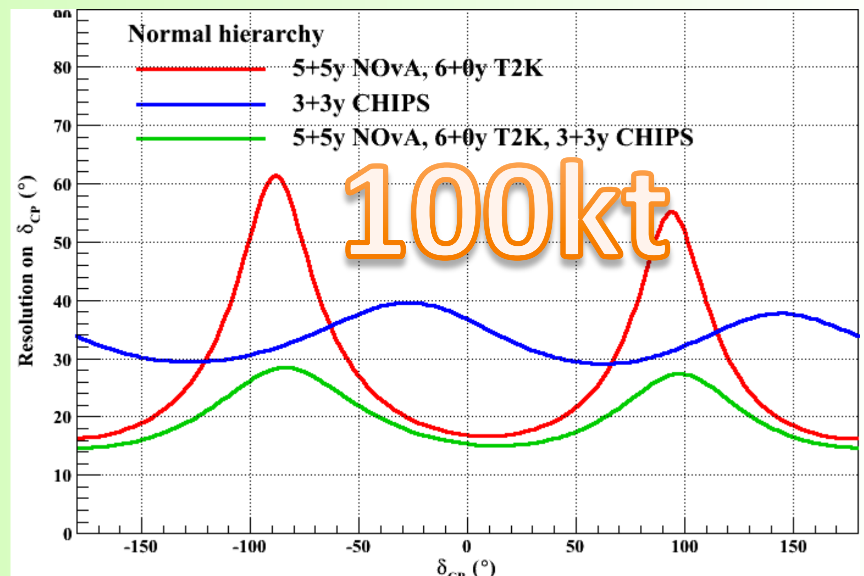
Looking At the NuMI Beam : Flux at the surface



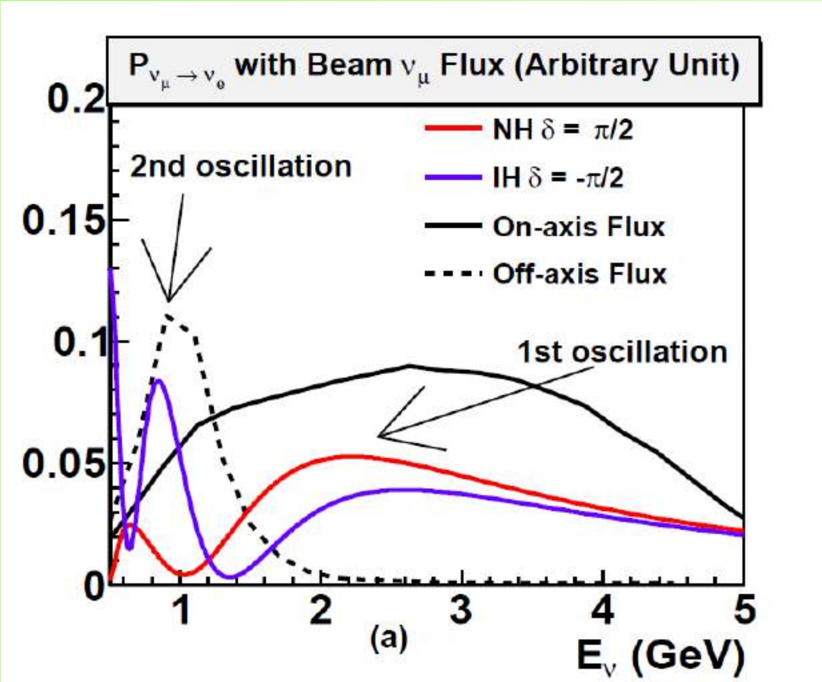
CHIPS@NuMI

- **Resolution on δ_{CP} is the Figure of Merit used throughout**
- 20% coverage of standard QE 10" tubes used in GLOBES: equivalent to 12% coverage of HQE 12"
- **All the calculations have assumed Super-K old-style efficiencies**
  - According to T2K, with new reco system a la MiniBOONE, efficiency and background rejection are much better
- Off-axis between 7-10mr gives best reach in δ_{cp}
  - More on-axis increases background, more off-axis reduces rate
- Ability to run in both ME and LE beam



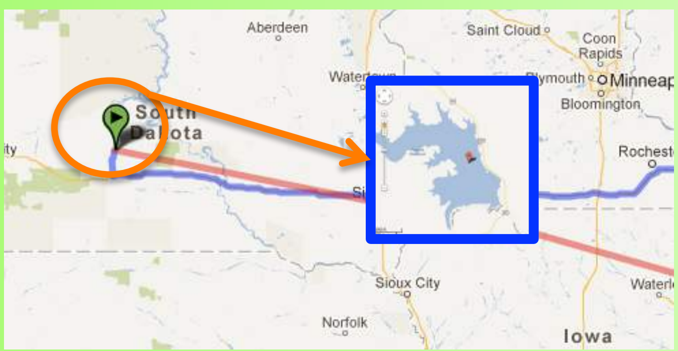


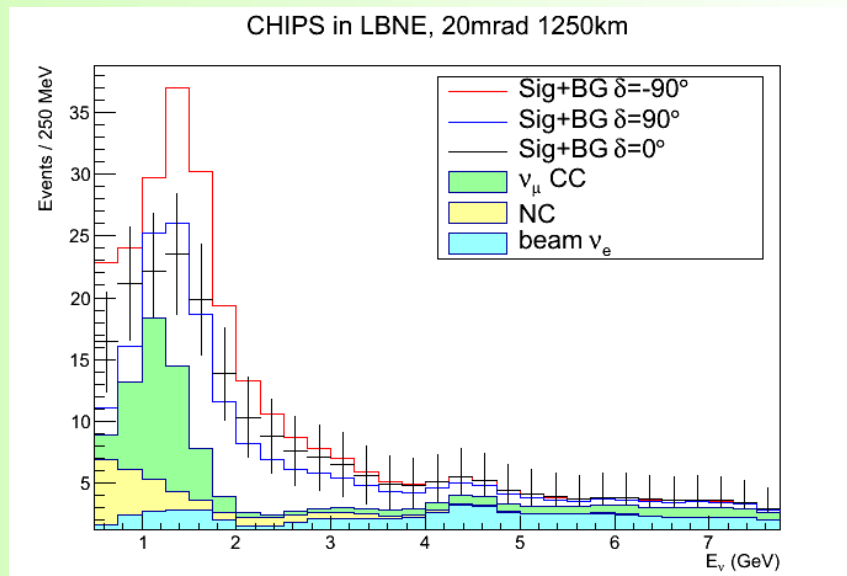
CHIPS@LBNE (20mr off axis)



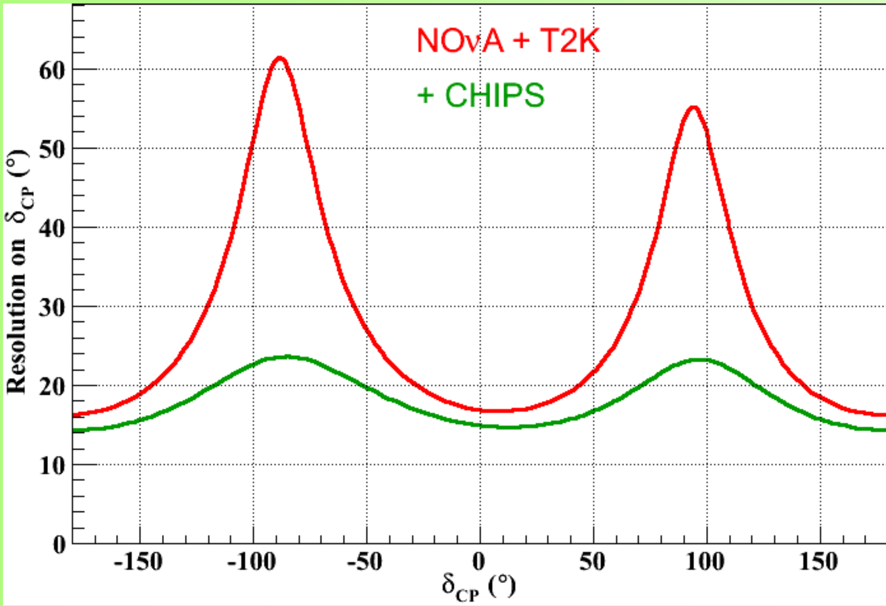
- 2^{nd} oscillation maximum located around 0.8 GeV
- Large quasi-elastic x-section
- Suitable for water Cerenkov detector
  - High efficiency for QE events
- 2^{nd} oscillation maximum is a necessary upgrade/augmentation path for LBNE

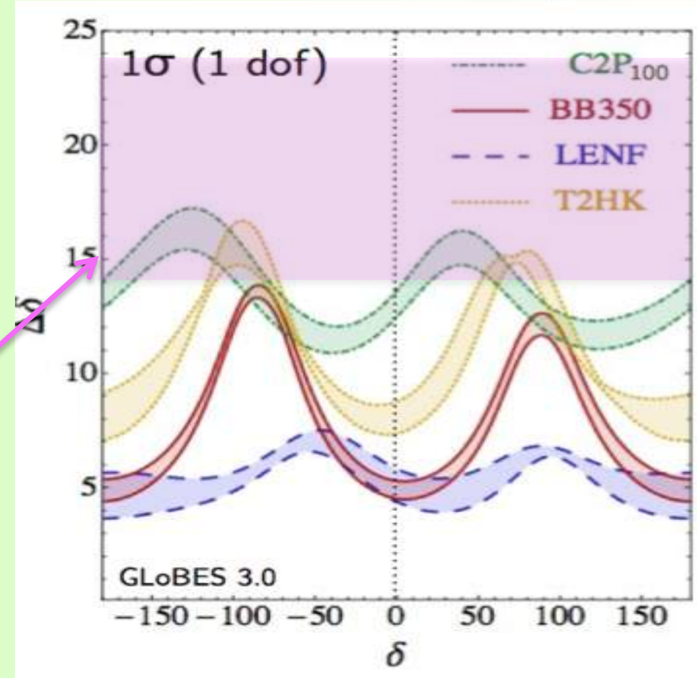
- There is (at least) one (40m depth) reservoir in the beam line @ 20mr (Pactola Resevoir, SD)





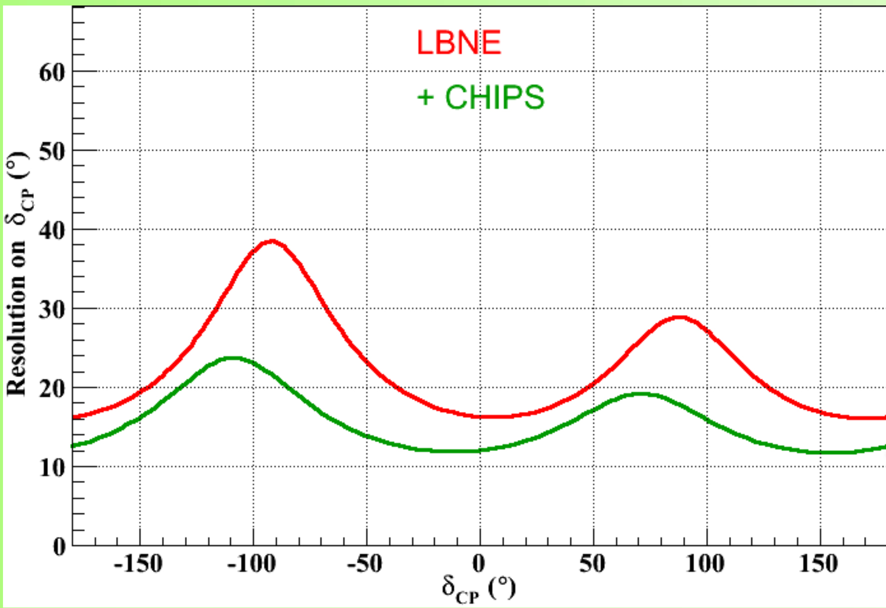
CHIPS@NuMI

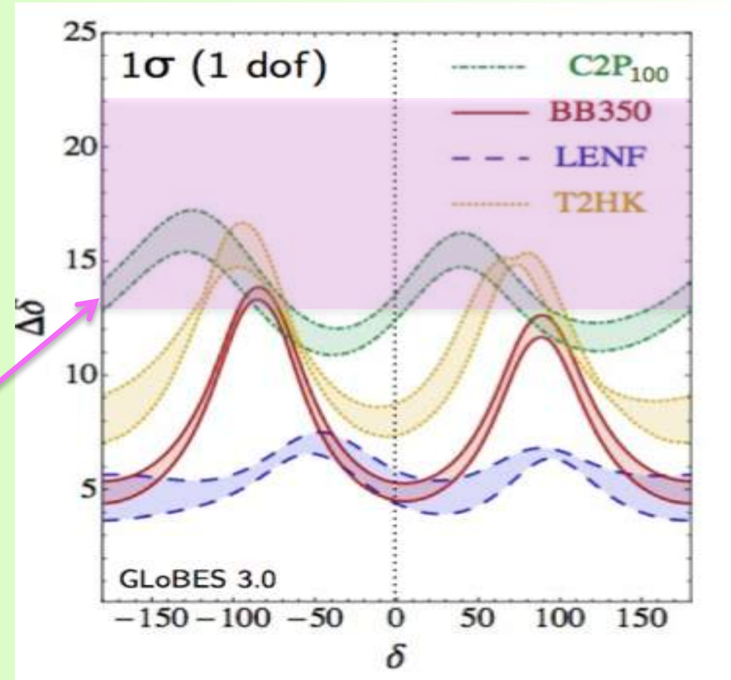




- CHIPS can make very big inroads into δcp
- LBNE could build SUBSTANTIALLY **on** CHIPS@NuMI and together **with** CHIPS@LBNE
- **10kt LAr+100kt CHIPS now on the same page as the NF!**

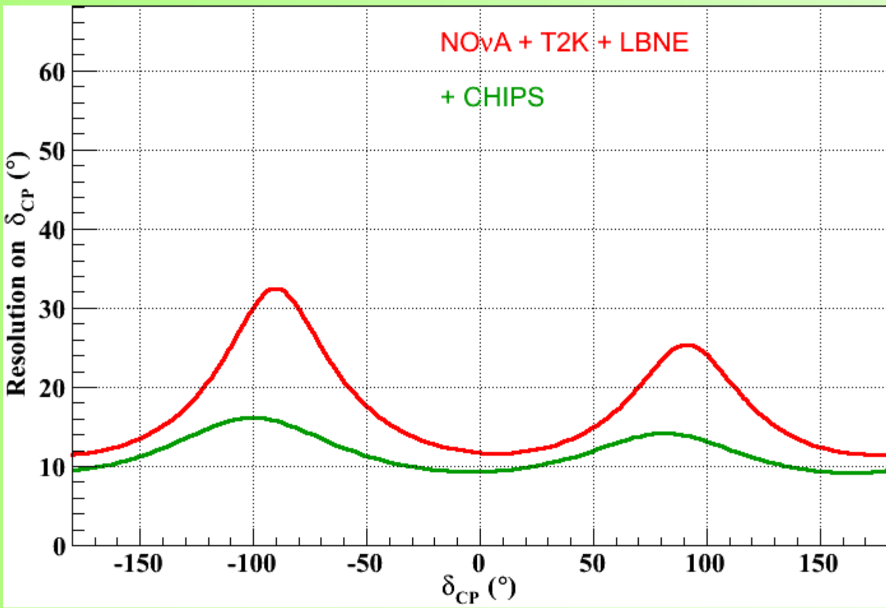
CHIPS@LBNE

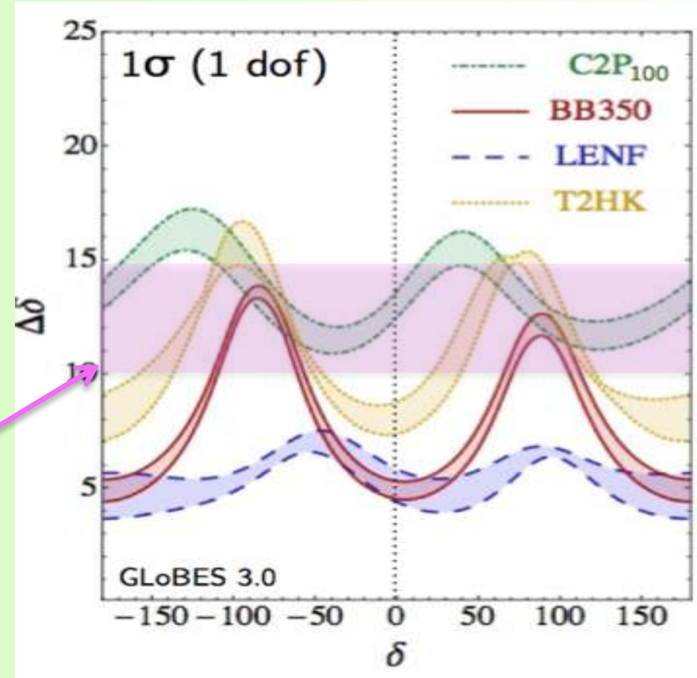




- CHIPS can make very big inroads into δcp
- LBNE could build SUBSTANTIALLY **on** CHIPS@NuMI and together **with** CHIPS@LBNE
- **10kt LAr+100kt CHIPS now on the same page as the NF!**

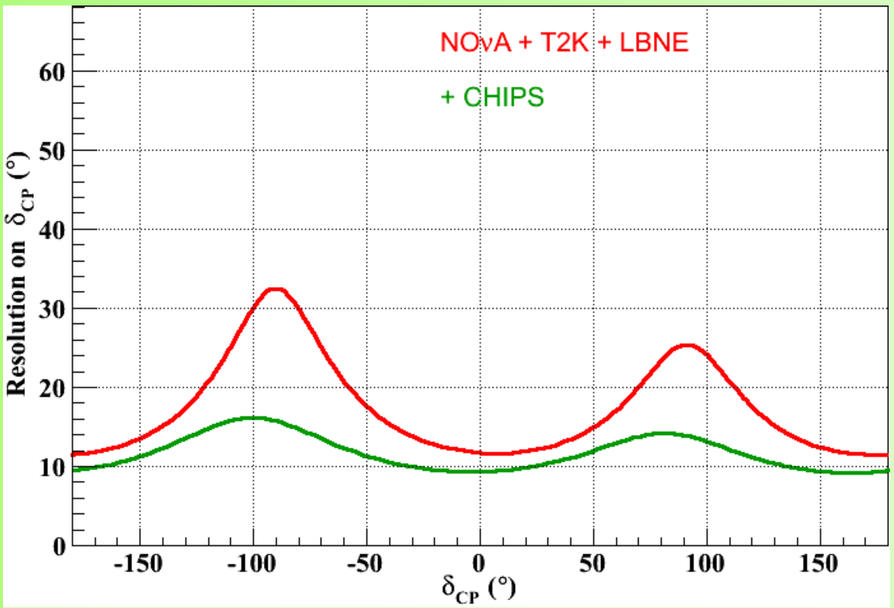
CHIPS@NuMI + CHIPS@LBNE

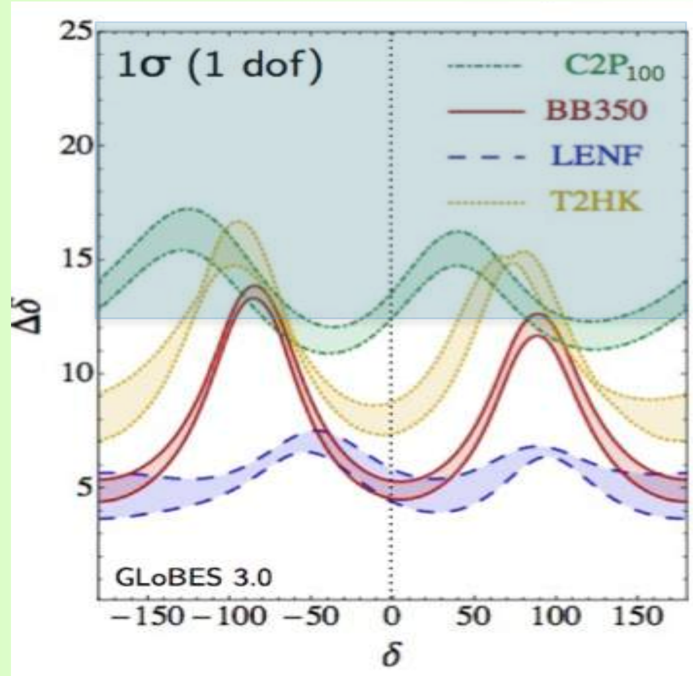




- CHIPS can make very big inroads into δcp
- LBNE could build SUBSTANTIALLY **on** CHIPS@NuMI and together **with** CHIPS@LBNE
- **10kt LAr+100kt CHIPS now on the same page as the NF!**

NO CHIPS

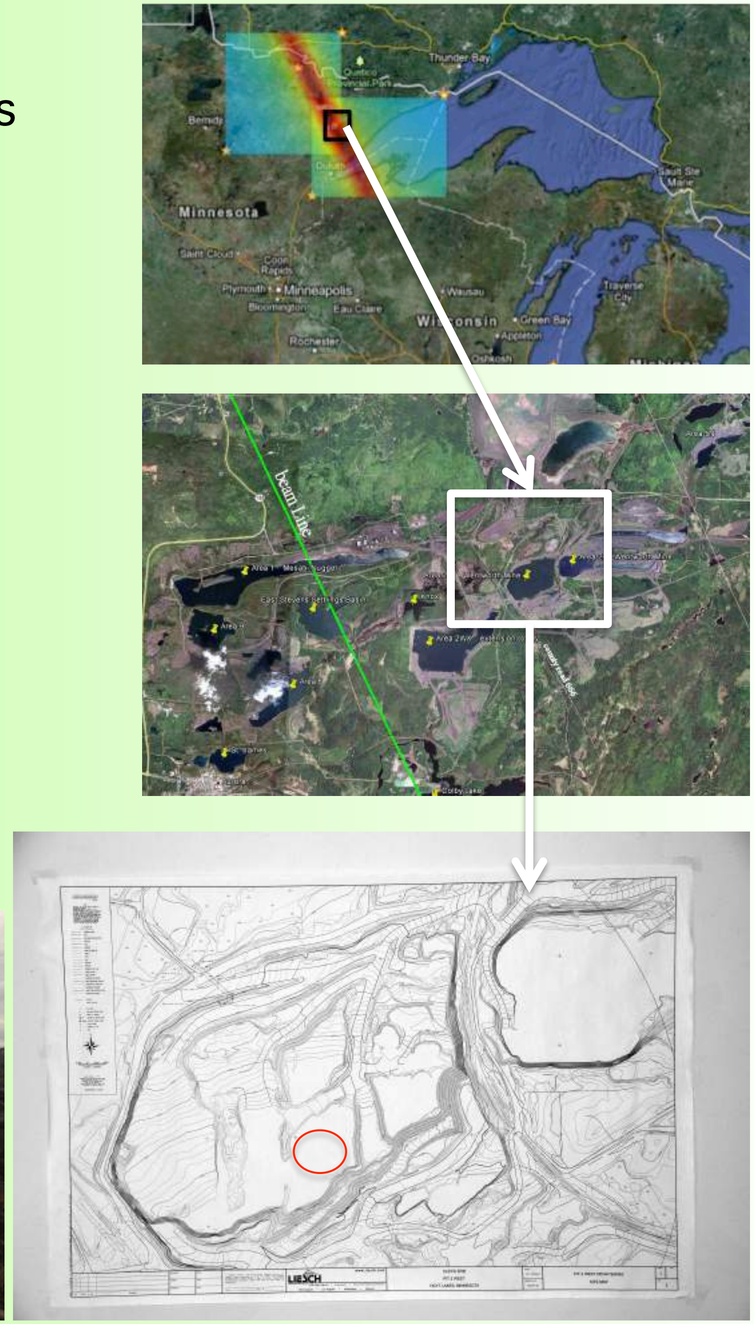




- CHIPS can make very big inroads into δcp
- LBNE could build SUBSTANTIALLY **on** CHIPS@NuMI and together **with** CHIPS@LBNE
- **Without CHIPS we are less.**

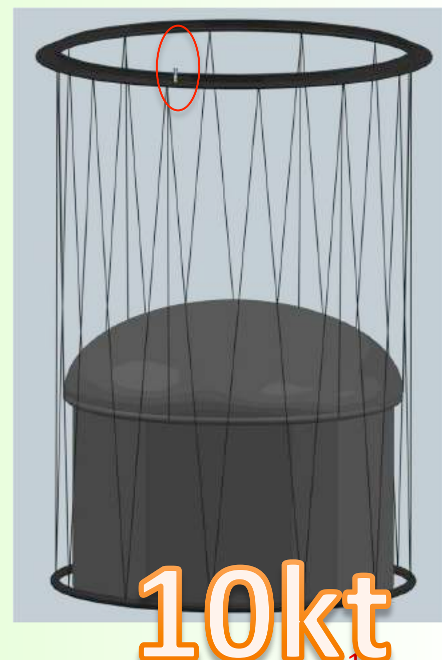
CHIPS : Wentworth Pit

- The Wentworth mine pit is 7mr off axis of the NuMI beam and > 60m deep
- Deeper region shown
- Two "beaches" (used to be a quarry)
- Electricity is already there at the two entrance points
- Secure environment
- The lawyers seemed willing to make it work
    - Agreement already drawn up to allow deployment of instruments into the water



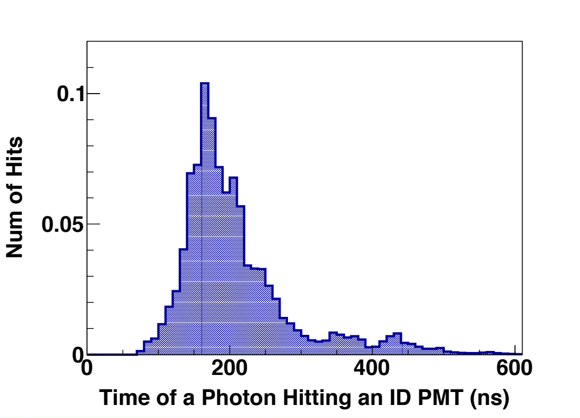
δ_{CP} : CHIPS concept

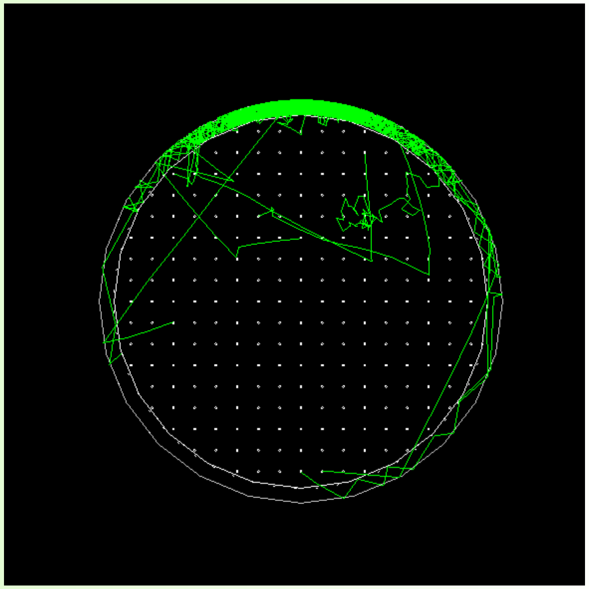
- Deploy from floating platform using industrial products from the fisheries industry
- Replace nets with PVC + KEE resevoir membranes rated for continuous underwater use including aggressive oil spill environments, low permeability and light tight
- Fill with cleaned water for neutrino target
- Pit water acts as mechanical support
- Deployment Idea developed by Madison/PSL groups for LBNE but has similarities with IMB and the GRANDE proposal

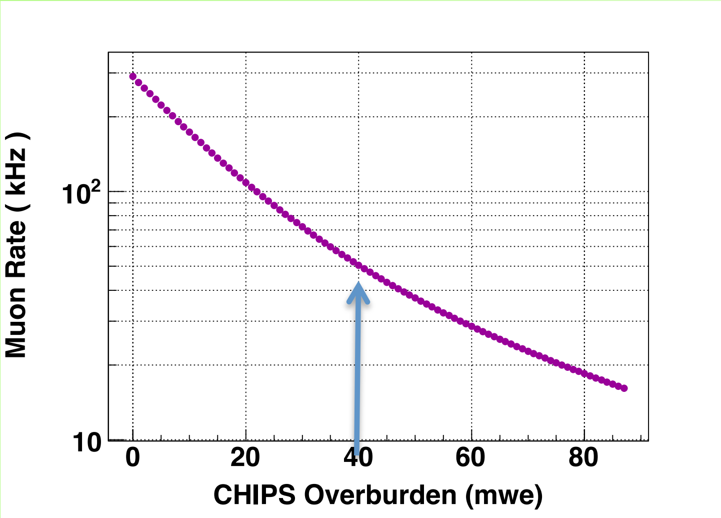


Cosmic Background

- Geant simulation of cosmic muons
- Muon rate expected to be 30-50kHz
- Inside volume event lasts up to 500ns
- One event every 20μs, beam spill 10μs
- Expected (conservative) dead time 2.5%
- High reflectivity leads to efficient veto







The R&D Programme

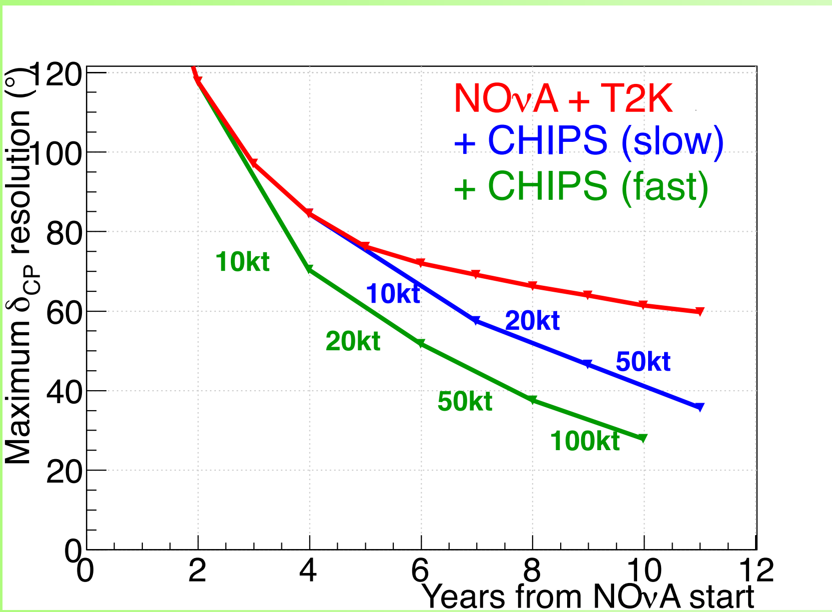
Progress this year and immediate plans

R&D program : Deliverables

- There are three deliverables within the overall CHIPS R&D program. These are:
  - The full engineering design of CHIPS-10 via the practical prototyping and verification of CHIPS-M, a 0.1kt model detector (year 1)
  - Construction of CHIPS-10, the 10kt prototype detector (years 2-5?)
  - the full engineering design for CHIPS-25 ("25" here refers to an educated guess of what the optimal module size will eventually be and is not prescriptive) (year 3)
- End result will be a working 10kt prototype producing physics by year 3 and a final design for CHIPS full-sized module (25-50kt, TBD)

Getting started fast

- Starting small can yield important results if we are fast

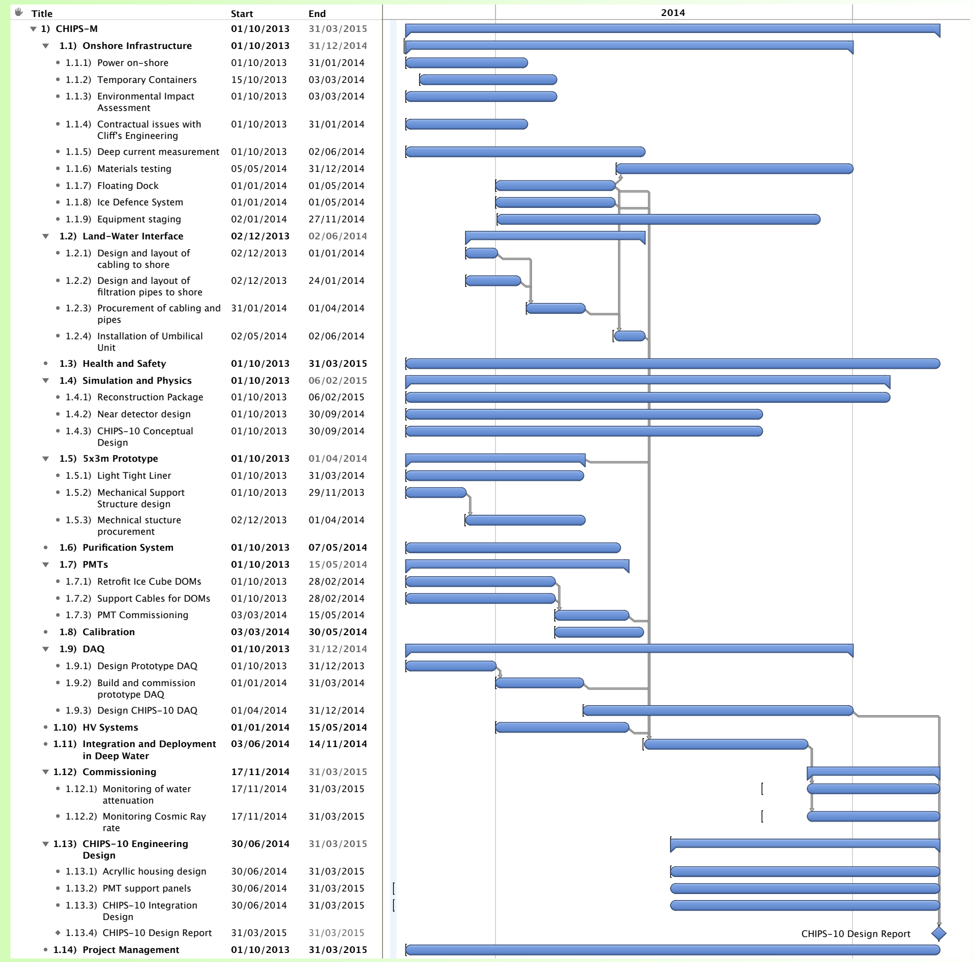


- Slow but continuous detector growth (\$3-10M/yr)
- Real costs fully understood using stepwise approach: avoid huge contingencies
- 100kt end result gives impressive gain over NOVA alone

- **Starting at all (!) can allow external money to be applied for**

R&D Plan for CHIPS-M (THIS YEAR $)

- CHIPS-M is 0.1kt
- 5m x 6m cylinder
- 5 ICECube DOMS+DAQ
- Identify beam events with spill time from GPS
- Practical prototyping of all major systems
- This GANTT chart demonstrates we have thought about how to do this project
- Brief description of WBS focuses on updates since R&D proposal

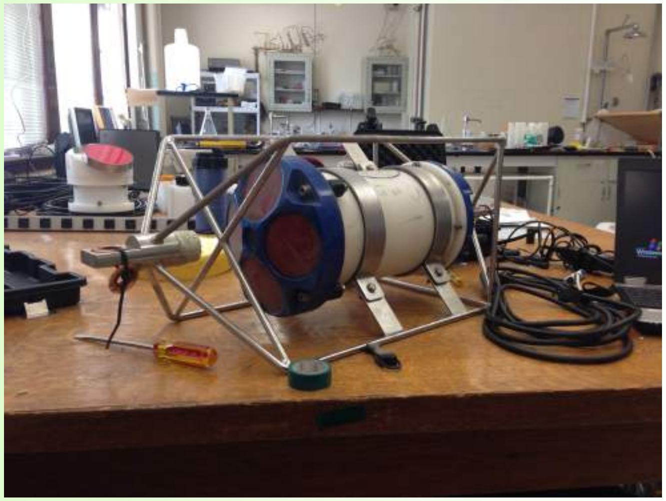


WBS 1.1 : Onshore Infrastructure

- NOVA trailer will be redeployed to house DAQ and Purification plant
- House for "guest-workers" identified in Hoyt Lake

WBS 1.1.5 : Deep Current Measurement

- Large Lake Observatory (UMD) collaborators monitored under lake currents October-November
- Chemistry and clarity already analysed for input to the purification system design
- ADCP- Acoustic Doppler Current Profiler to estimate currents
  - Uses Doppler shift of scattering particulates floating in the water to estimate velocity
- Water very clear : perhaps clearer than tolerance of instruments
- Thermistors characterized thermal stratification
  - "Textbook" thermal profile



WBS 1.2: Land Water Interface

- Floating platform out to detector
- Cable Umbilicals will carry signal and power cables
- Ice defence (pumps) will be installed where pipes emerge and around floating dock

- Installed as needed adjacent to the floating collar
- 4’ x 6’ Float $220, buoyancy ~1 ton

WBS 1.3 : Health and Safety

- No Divers
- No Boats
- UM Duluth LLO safety expertise and personnel
- 3 month deployment period between the ice
- Planning and practice in Soudan surface building
- Training for all workers

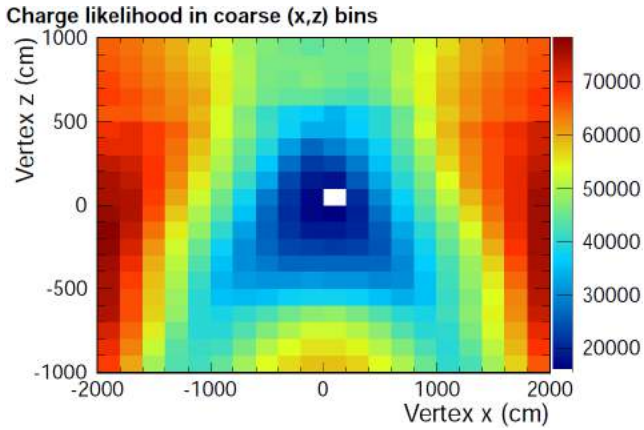
WBS 1.4 : Simulation and Reconstruction

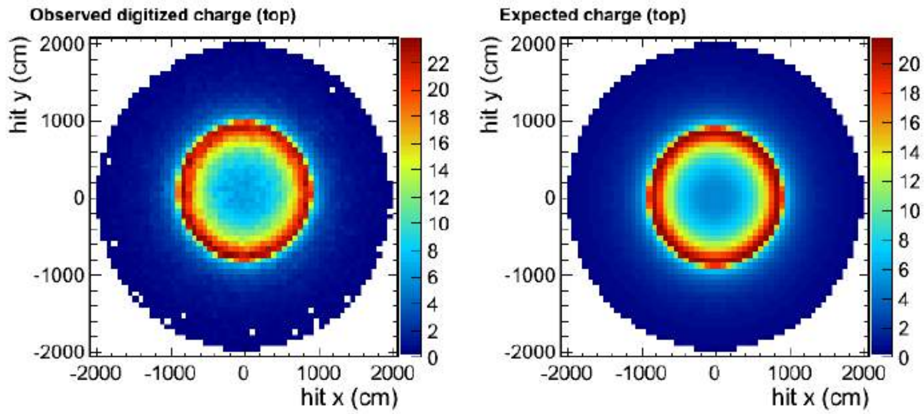
- Simple design of previous water Cherenkov detectors has not had the luxury of real simulation before construction
- Certain questions need to be answered
  - For the specific mission of CHIPS, to reject π^0 events and accept ν_e events in a neutrino beam
    - Is uniform coverage the best solution?
    - Is uniform PMT size the best solution?
    - Are there cost savings to be made by optimizing the above?
- The package (when completed) will be a very Useful Tool.
- Super-K now have this also, but we don't (yet)

- Standing on the shoulders of giants
  - GEANT-4 based WCSim has been written and we have just modified the geometry
  - This was developed for the LBNE WC effort
  - Further mods including mixing large and small PMTs is part of the ongoing program

- Reconstruction based on the MiniBOONE approach
  - Predicts charge and time distributions for a set of track parameters and fits using maximum liklihood

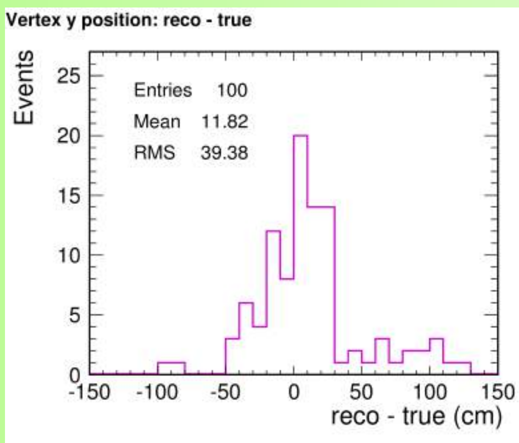
WBS 1.4 :Simulation and Reconstruction

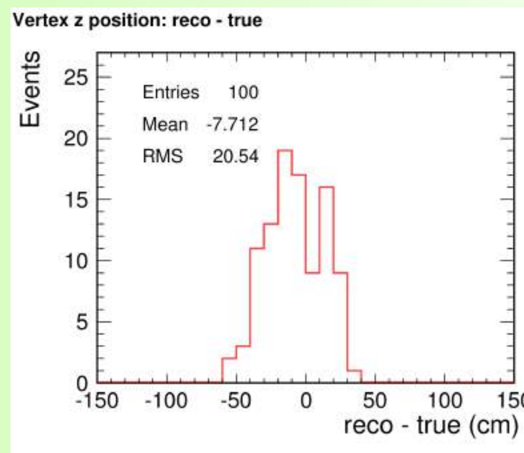




Likelihood in x,z for a 1.5GeV muon travelling in the +ve z direction from the origin. The minimum is found correctly at (0,0).

Observed (left) and predicted (right) charge for an electron travelling from the origin towards the top cap of a cylindrical detector. The colour axis shows the charge in PE.

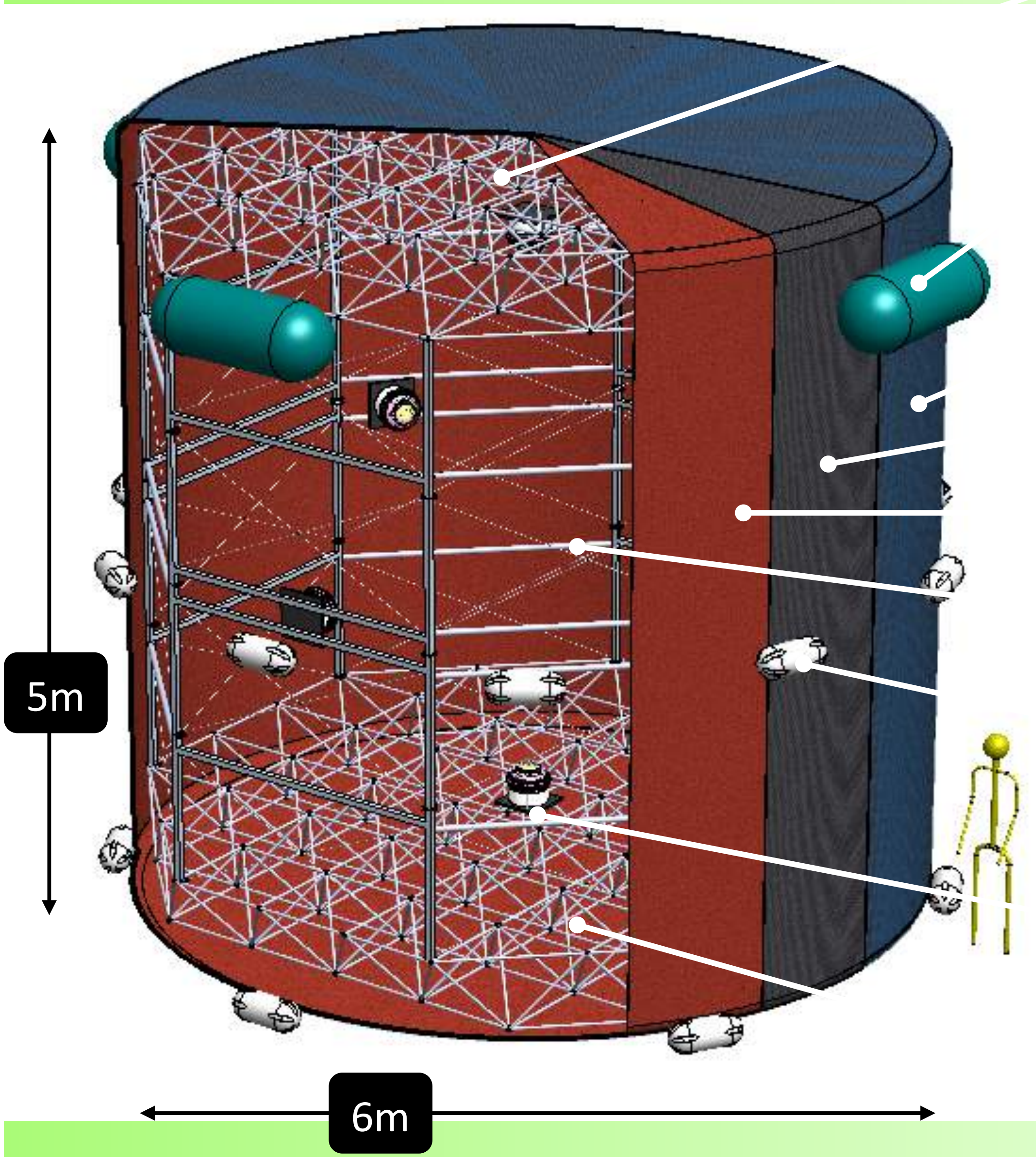




Plots for 1500MeV muons, travelling from (1m, -2m, 3.2m) in the (1,0,1) direction.

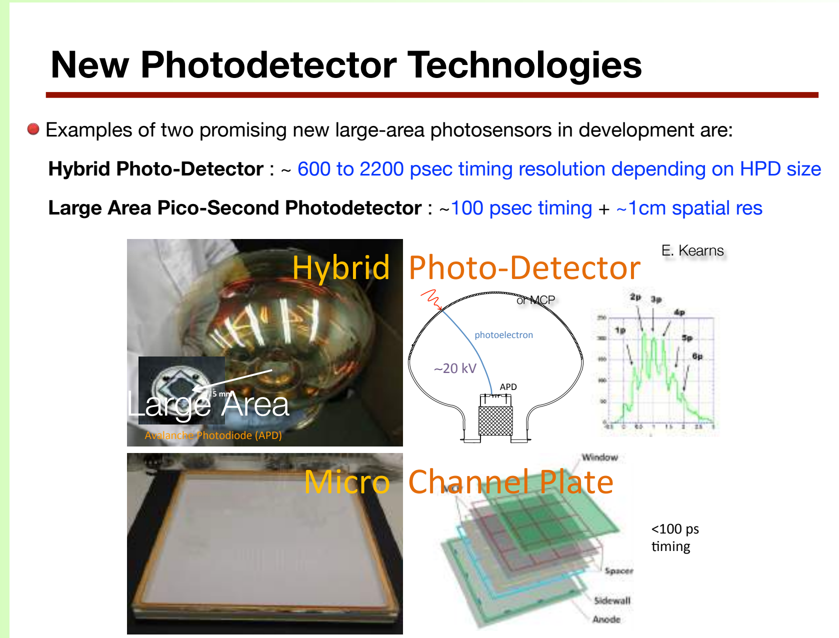
Use charge distribution to fit the vertex position, with the energy and direction fixed.

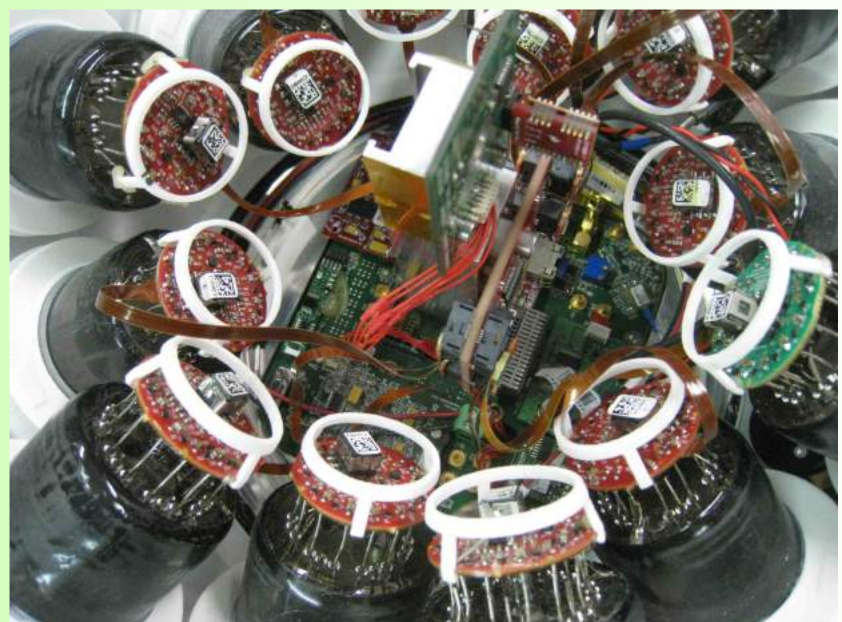
WBS 1.5: CHIPS-M Vessel



WBS 1.7: PMTs

- PMTs are the major cost driver
  - Pushing on PMT technology as well as increasing competition will be a plank of the CHIPS philosophy
- Also in contact with KM3Net collaboration
  - Electronics developed already for a 31x3"PMT DOM
  - This may actually be better for us than large tubes
  - Have received pieces from NIKEF at UT to benchmark





WBS 1.11: Integration and Deployment

- Integration will first happen at the Soudan Surface building
- Presently we are relying on an army of volunteers for the commissioning: undergrads, grad-students, post-docs and academics to save money
  - **Experience for students almost without comparison!**
  - Safety and construction training essential beforehand
  - Military training obviously an advantage ☺

WBS 1.12 : Commissioning

- Commissioning will take place with undergrads, grad-students, post-docs and academics
  - Analysis of data much more time consuming in the first instance, and to pick out the beam spill will be very challenging
    - We expect about 1000 muons / year from the beam
  - Another great learning experience for the students

WBS 1.13 : CHIPS-10 Design

- Just to summarize : in parallel to CHIPS-M construction, design effort for CHIPS-10 will be ongoing
  - PMT Panel design
  - DAQ design
  - Electronics "design"
  - Simulation to inform choice of PMTs

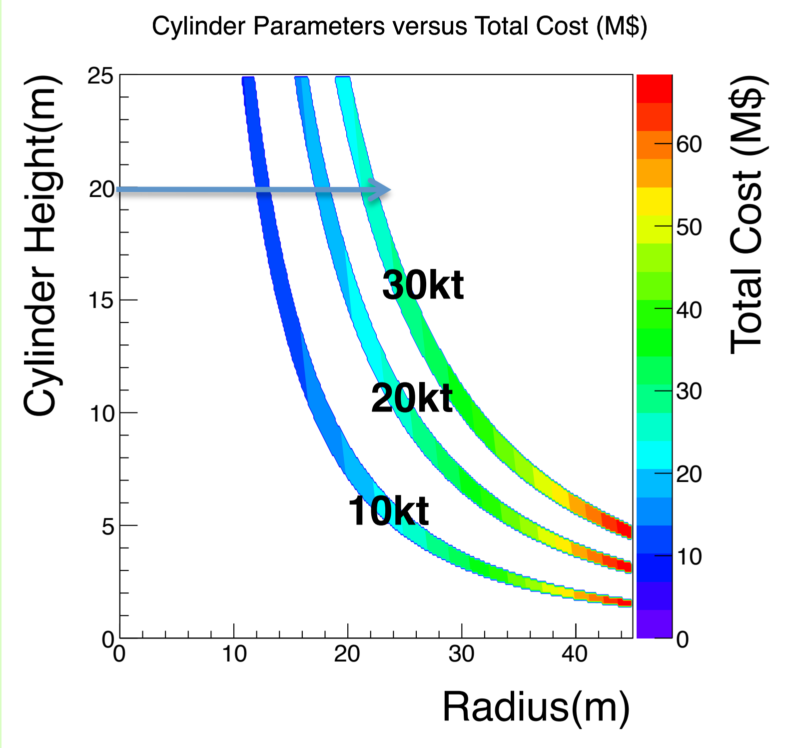
CHIPS costings

- CHIPS-10 calls for 6000 12” PMTs,
- CHIPS-25 calls for 13000 12” PMTs, costs based on 12”

Item	Cost per Channel
PMT, 12” HQE	$1,800
Frame Housing	$34
Base Encapsulation	$93
HV Base	$34
HV Supplies	$45
Front End,trigger,DAQ	$80
Cables	$150
PIU (support framing)	$200
Total per channel	$2,436
Total 13K channels	$33,750,000
Engineering Cost	$3,000,000

Table 4: Cost of the PMT assemblies

Item	First 50 m×20 m module (DxH)	Additional modules
Engineering	$1,000,000	$200,000
Marine Cage Superstructure, 3 rings	$250,000	$250,000
Steel framework for liner support	$1,000,000	$1,000,000
Liner ($50 m^{-2})	$500,000	$500,000
Deploy PMT modules, 9 FTEs	$900,000	$600,000
Water Purification System	$1,400,000	$1,400,000
Total	$5,050,000	$3,950,000



Costs for year 1 and (rough) projection

WBS	item	materials cost	effort cost	in kind	total
1.1	**Onshore Infrastructure**	**21k**		UMn	**21k**
1.1.1	On-shore power		in kind	UMn	
1.1.2	Shipping Containers	6k	in kind	UMn	6k
1.1.3	Environmental Impact		in kind	UMn	
1.1.4	Cliff's Engineering		in kind	UMn	
1.1.6	Materials Testing		in kind	UMnD	
1.1.7	Professional Moorings	10k	inclusive		10k
1.1.8	Ice Defense System	5k	in kind	UMnD	5k
1.1.9	Equipment Staging		in kind	UMn	
1.2	**Land Water Interface**	**15k**		UMn	**15k**
1.2.1	10xHV/signal cables(1.3km)	5k	in kind	W&M	5k
1.2.2	Purification pipes (200m)	5k	in kind	UCL	5k
1.2.3	Floating Dock	5k	in kind	UMnD	5k
1.3	**Health and Safety**		15k	UMn	**15k**
1.4	**Software**			UCL,UM,ISU	
1.5	**CHIPS-M Vessel**	**35k**	**30k**		**70k**
1.5.1	liner	10k	in kind	UW	10k
1.5.2	support frame design	15k	15k	UW,UC	30k
1.5.3	support frame procurement	15k	15k	UW,UC	30k
1.6	**Purification System**	**25k**	in kind	UMn	**25k**
1.7	**PMTs**	**3k**		UM,UT	**3k**
1.7.1	Borrow Ice Cube DOMs		in kind	UW	
1.8	**Calibration**	**10k**	in kind	CIT,ISU	**10k**
1.9	**DAQ system**	**5k**	in kind	UK	**5k**
1.10	**HV System**	**5k**	in kind	W&M	**5k**
1.10.1	Twisted Pair Cables	5k	in kind	W&M	5k
1.11	**Integration and Deployment**		**60k**	All groups	**60k**
1.12	**Commissioning**		**20k**	All groups	**20k**
1.13	**CHIPS-10 Engineering Design**	**5k**	**105k**		**110k**
1.13.1	Acryllic housing design		20k	UW,UT	20k
1.13.2	PMT support panel design		20k	UC	20k
1.13.3	CHIPS-10 Integration design		20k	W&M	20k
1.13.4	Electronics development	5k	20k	UPitt	25k
1.13.6	CHIPS-10 support frame design		25k	UW	25k
1.13.6	CHIPS-10 Technical Design Report				
1.14	**Project Management**		**20k**	Consultant	**20k**

Table 2: : Cost breakdown of first year activities (CY 2014): \$379k Total. Given the likely funding profile, full funding will likely not be available until May or June of 2014. In that case, the WBS 1.13 could be started after May as this does not need to reach the prototype phase until after the winter of 2014.

WBS	Total	FY1	FY2	FY3	FY4	FY5
X.1. Onshore Infrastructure	**592k**	26k	212k	127k	127k	100k
X.2. Land Water Interface	**390k**	10k	15k	65k	100k	200k
X.3. Health & Safety	**75k**	15k	15k	15k	15k	15k
X.5. Prototypes	**410k**	40k	370k			
X.6. Purification System	**870k**	25k	45k	400k	400k	
X.7. PMTs	**6961k**	3k	78k	480k	1600k	4800k
X.8. Calibration	**110k**	10k	10k	30k	30k	30k
X.9. DAQ	**817k**	20k	42k	35k	180k	540k
X.10. HV system	**185k**	5k	5k	25k	75k	75k
X.11. Deployment	**460k**	60k	100k	100k	100k	100k
X.12. Commissioning	**420k**	20k	100k	100k	100k	100k
X.13. CHIPS-10,25 Design	**115k**	95k	20k			
X.14. Project Management	**450k**	50k	100k	100k	100k	100k
TOTAL	**11855k**	**379k**	**1112k**	**1477k**	**2827k**	**6060k**

Table 5: : Cost Summary Table

- Total Cost 379k this year (2014): of that
  - 105k CHIPS-10 engineering for next year's (2015) deployment

Pledges of money and manpower

- So far we have some small money pledges which have allowed us to get started
  - Some more concrete than others
- Shortfall is $220k for minimum program with little contingency
  - Risk is that follow on of CHIPS-10 vessel deployment is delayed as design is not completed
- $320k will allow us to succeed in carrying out the first year program and be ready for 2nd year

Funder	Cash($k)	(FTE)	Individuals	Contribution	Potential Bids ($k)
UCL	35	1.1	(2S+1P+3A)	DAQ/Management/Simulation	
Manchester	10	0.5	(1P+2A)	DAQ/Simulation	
U.Minn	30	0.7	(1T+1P+2A)	Staging/Project Engineer	
UW Madison		0.2	(1RP)	5 IceCube DOMs and DAQ(loan)	
UT Austin	3	0.8	(2S+1E+1A)	PMT Engineering/Machine Shop	
U.Pitt	5	0.3	(1S+1P+2A)	Electronics Development/Design	
CalTech	20	0.3	(1A)	Calibration/Technical Effort	
Tufts		0.3	(1P)		
Cincinati	5	0.2	(1P+2A)	Machine Shop	50(EAGER?)
W&M	5	0.2	(3U+1P+3A)	design/machine shop/HV	50(EAGER?)
Duluth		0.2	(1U+1C+1A)	Water Study, Management	50(INSPIRE?)
Iowa State		0.5	(1P+1A)	Calibration/ND Design	
STFC/RS (UK)	40			Deployment/Management	
total	153	5.3	39 (19 A)		150

Table 6: : University Contribution in kind for year 1: S=grad student, P=postdoc, T=technician, A=academic, U=undergrad, E=engineer, RP=research professor

Collaboration Structure

- 13 US institutions: UW, UMn, UMnD, UMnD-LLO, CIT, W&M, CU, FNAL, BNL, UPitt, ISU, Standford, UT, Tufts
- 2 UK institutions: Manchester and UCL
- Presently, we have a funders group
  - Reps of all groups who have contributed money
- Most responsibilities nominally defined but certainly room for new members
- If proposal successful, Institutional Board will be formed
  - One person per institution
- Spokespeople will be elected by IB
- Technical Board will be appointed by Spokespeople
  - Technical experts to make technical decisions

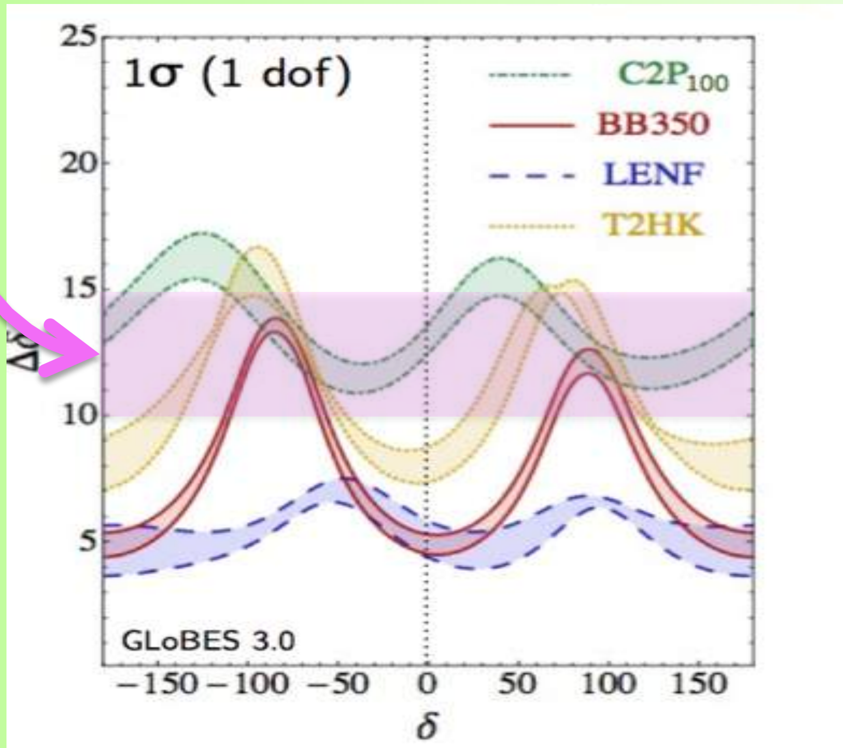
SUMMARY

- There is an undeniable physics case for developing a large water Cherenkov detector in the NuMI beam
  - Redeploying it later in the LBNE beam will lead to faster progress and further reach for LBNE (even 10kt) than presently planned
- Work has already started for the first year's task of proving the viability of the idea
  - Funds are needed of up to $300k to complete this first year's goals
- A full technical review would be expected at the end of this year along with a bid for funds for the CHIPS-10 vessel
- But the bottom line is ……

BOTTOM LINE

- Collecting the NuMI neutrinos in CHIPS and then redeploying CHIPS in the LBNE beam is a game changer for the final reach of LBNE

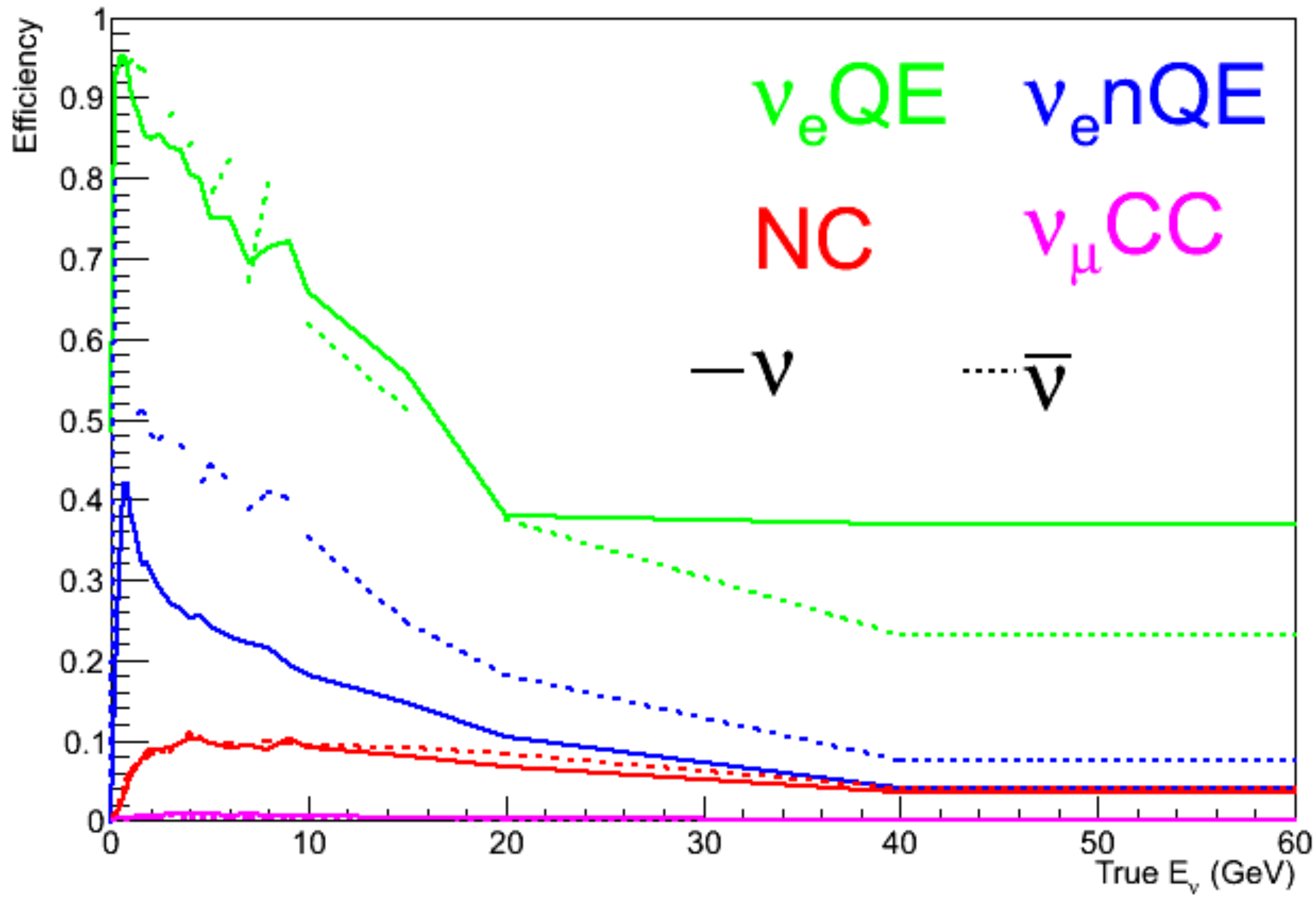
+CHIPS
(+LBNE
+NOVA
+T2K
+MINOS)



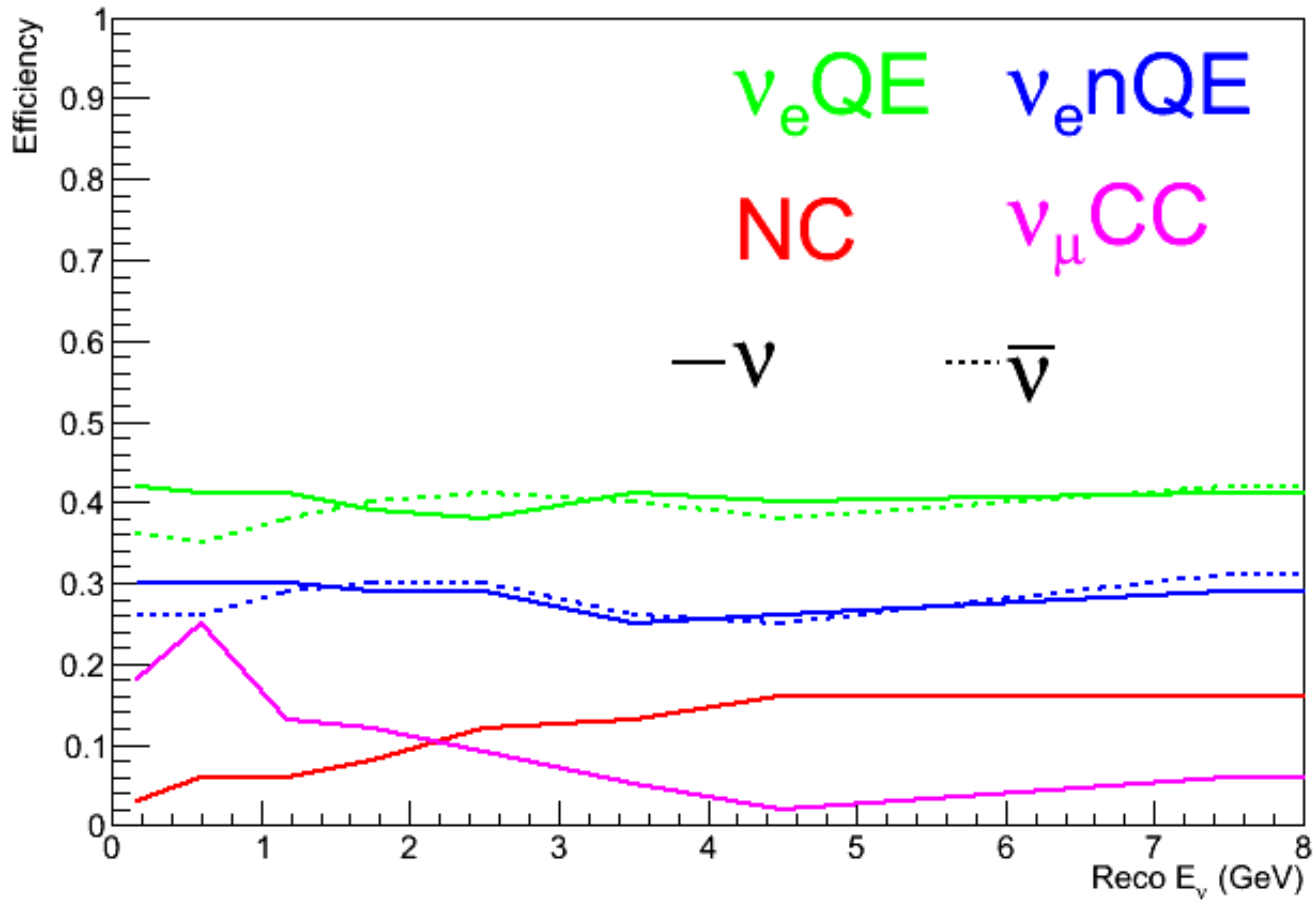
Pilar Coloma, NuFACT 2012

BACKUP SLIDES

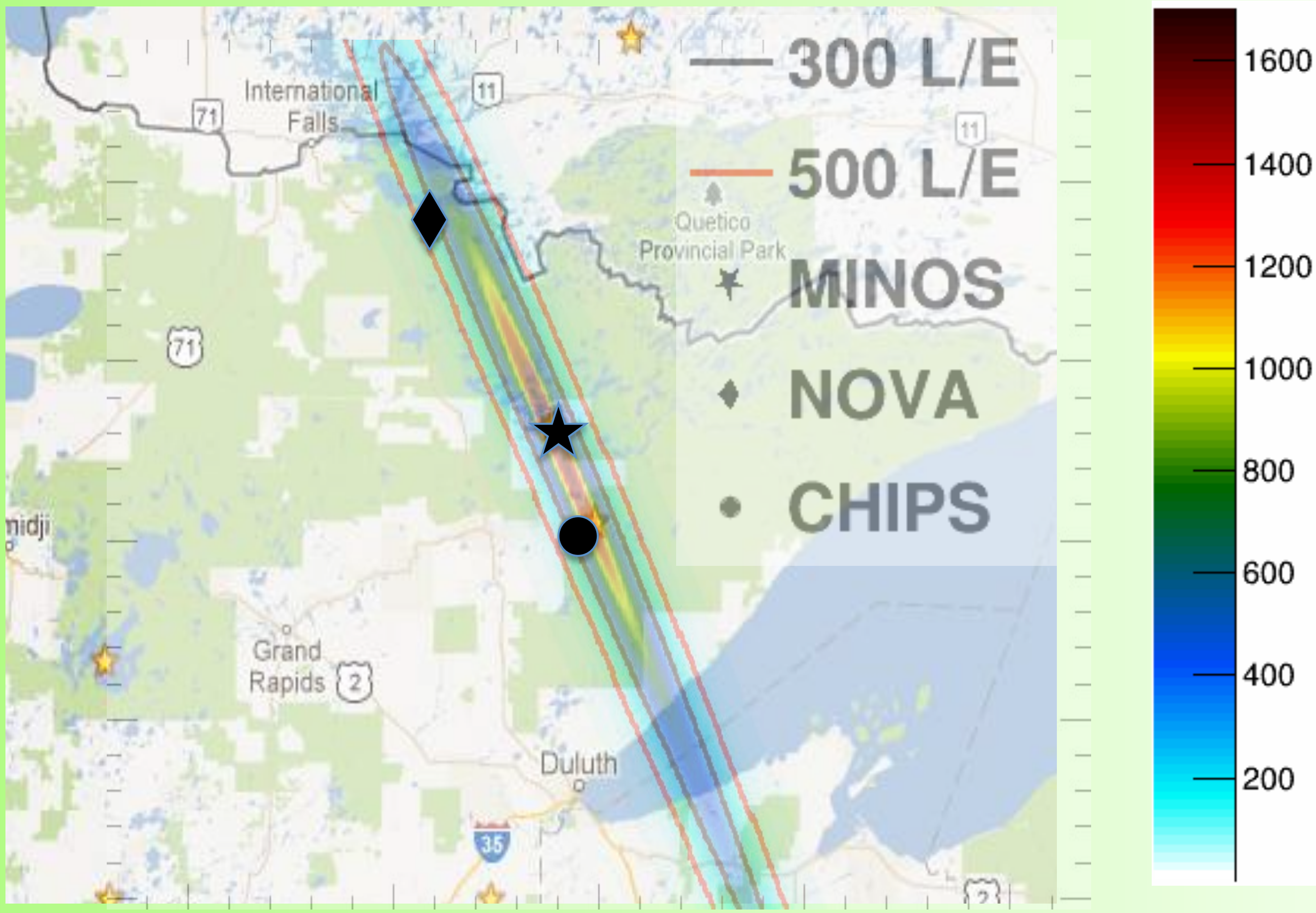
Input to GLOBES



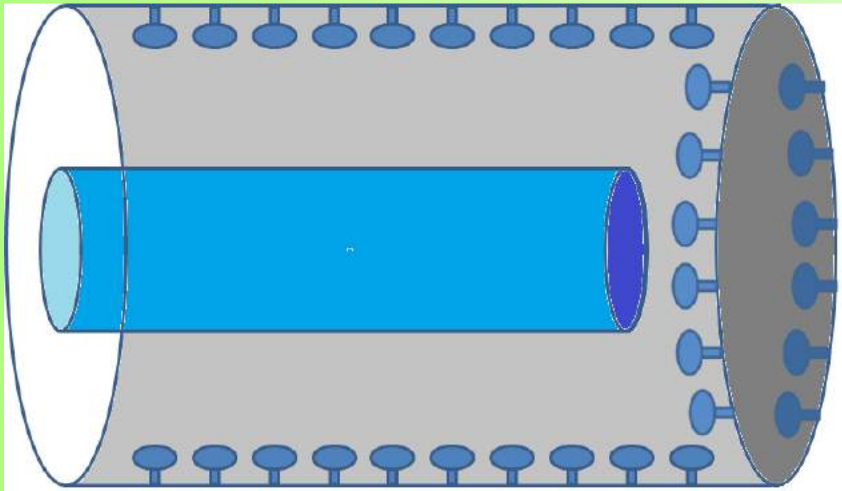
Input to GLOBES



Looking at the NuMI Beam : Events/kty



Near Detector Concept

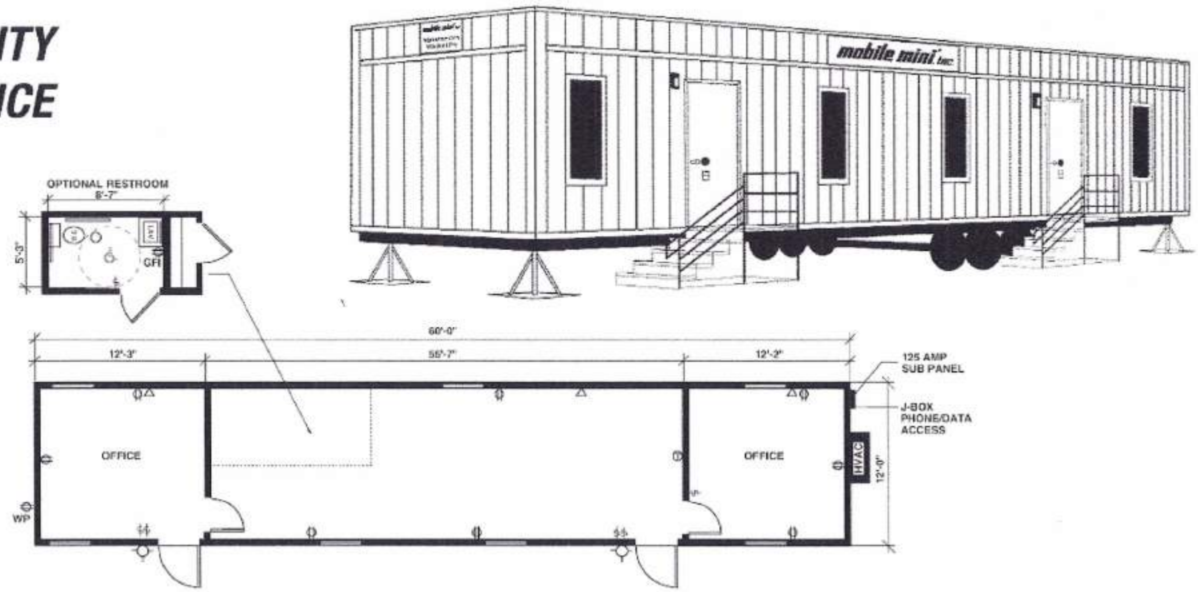


- Minerva with water target might be another option
- Need to understand exactly what ND would be used for

- Potential use for fast PMTs here…
- Small water volume leads to small number of events per spill
- MINOS ND as muon catcher
- MC must model ND performance : this true in any case
- Lots of interesting development to be done

WBS 1.1 : Onshore Infrastructure

HIGH SECURITY MOBILE OFFICE 12' x 60'



Standard Specifications

Size
- *64' Long (including hitch)*
- *60' Long box size*
- *12' Wide*
- *8' Ceiling height*

* *High Security Features*

Interior Finish
- *Wood grain paneled walls*
- *Vinyl tile floors*
- *T-Grid ceiling*
- *Private offices (2)*

Insulation
- *R-11 walls and floor*
- *R-11 ceiling*

Electric
- *Fluorescent ceiling lights*
- *125 amp breaker panel*
- *120/240 Volt single phase*
- *Exterior J box for interior phone/data jack access*
- **Vandal resistant exterior lights at all doors*

Heating and Cooling
- *Central HVAC*
- *Supply and return duct*

Windows/Doors
- *Horizontal slider windows w/screens*
- **Interior security bars*
- *Hydraulic door closures*
- *Mini blinds*
- **Steel doors w/ security plates w/ heavy duty entry lock set*
- **Optional: MMI high security door system w/ 3 pt interior locking system*

Exterior Finish/Frame
- *Treated wood siding*
- *I-Beam frame*
- *Standard drip rail gutters*
- *40 lb. roof load*
- *Detachable hitch*

Legend

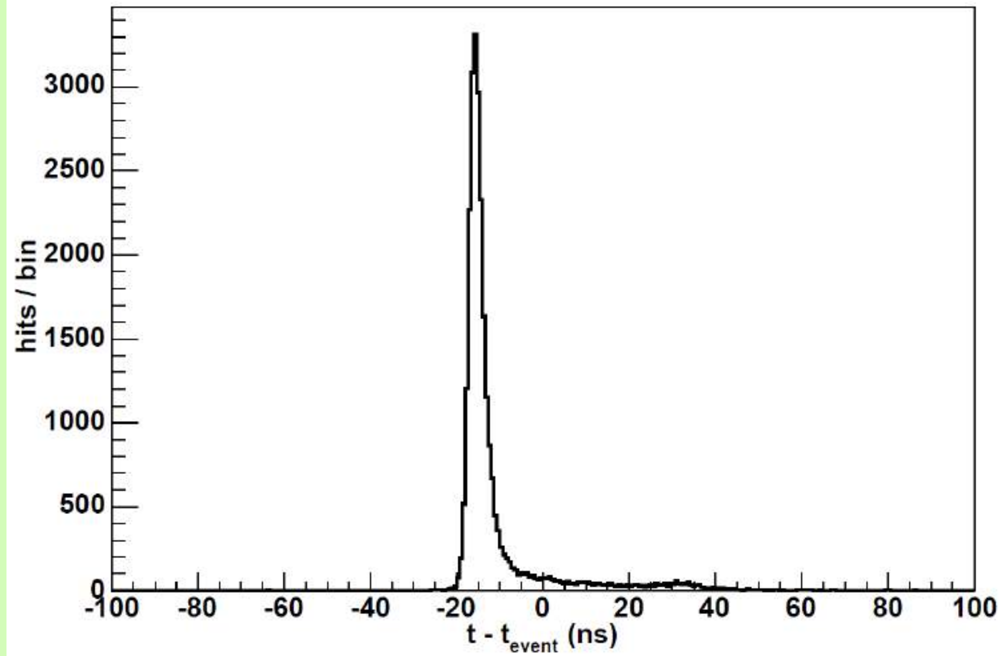
Symbol	Description	Symbol	Description
-O-	Exterior lights	⊖WP	Duplex receptacle - 15 amp w/ grnd & wthr cvr (includes phone access panel)
⸸	Single pull switch	△	J-box (phone/data)
⸸⸸	Double switch	ⓣ	Thermostat
⊖	Duplex receptacle - 15 amp		

www.mobilemini.com

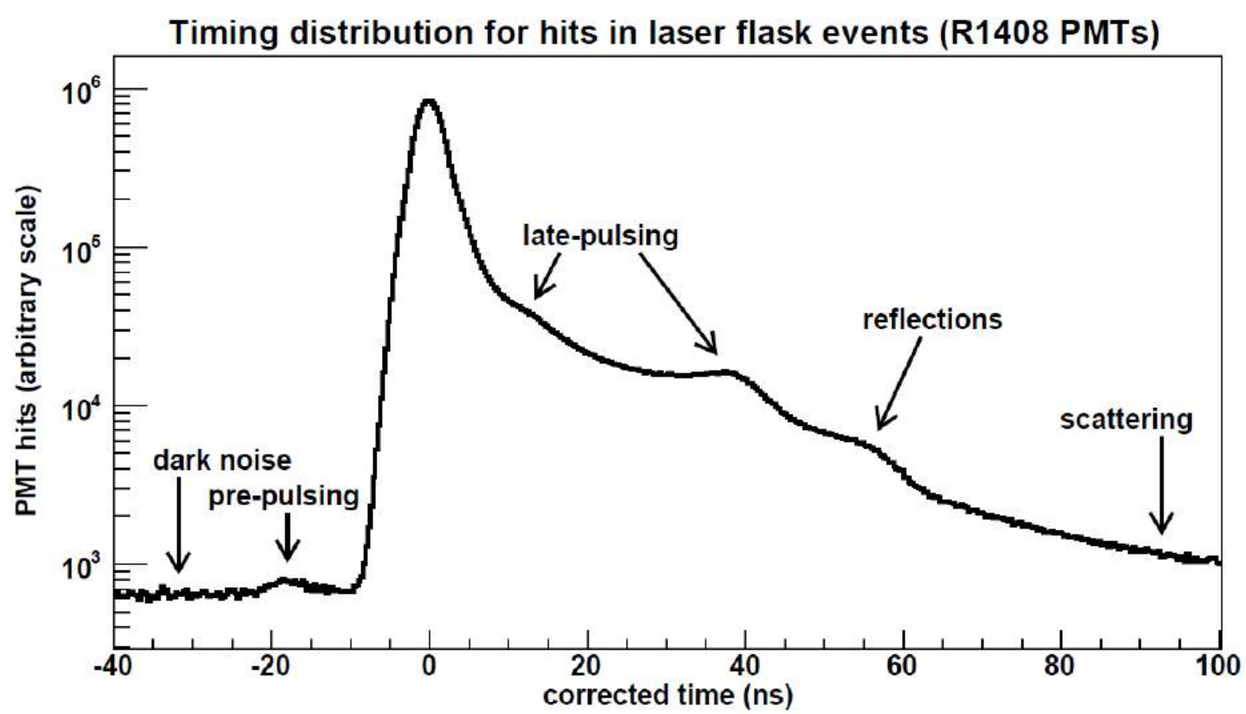
mobile mini, inc.®
The Storage & Office Solution Specialists
1-800-950-6464

© 2002 Mobile Mini, Inc., All rights reserved. Form [illegible]

Basic timing distribution for a single detector channel obtained using the central laser flask.
(Timing offset, resolution) →



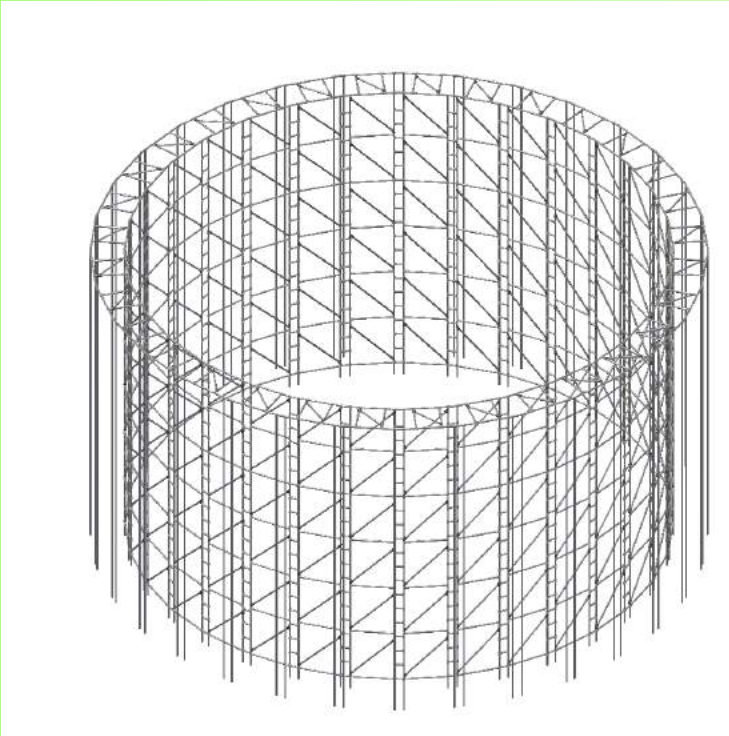
Eventually: detailed understanding of the optical properties of the detector (both the optical medium and photodetectors)

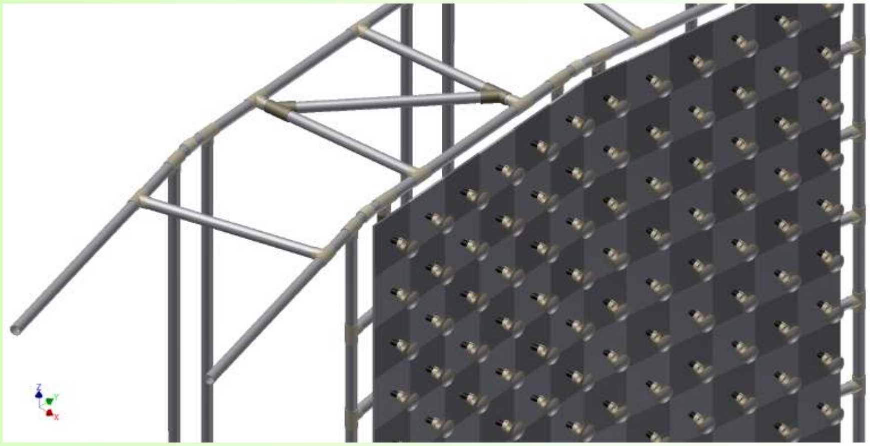


(Some timing features shown here; also many interesting [and relevant] charge response features where laser system helped.)

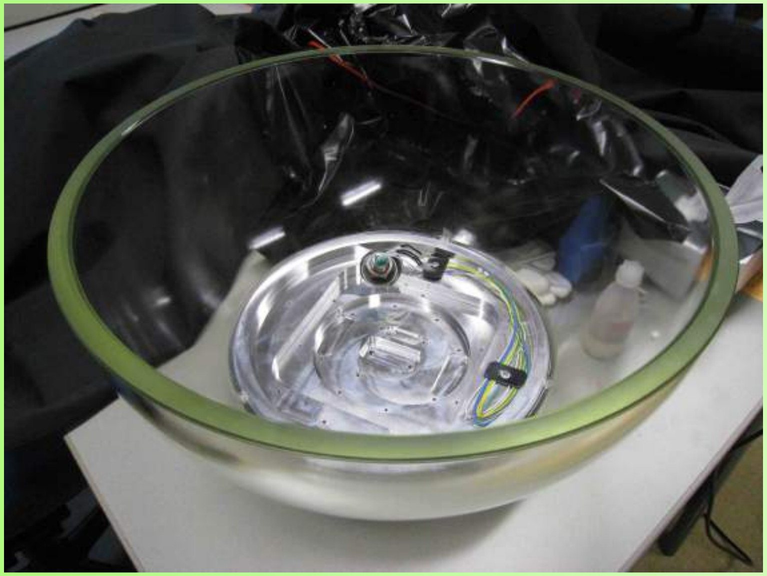
WBS 1.5.2: Mechanical Structure

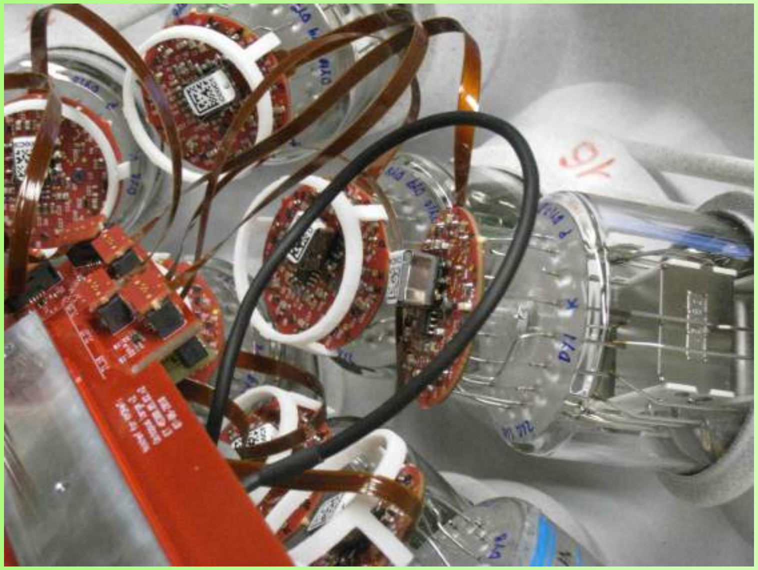
- Structure will support light tight liner on the outside and PMT (almost light tight) panels on the inside
- Space for veto region



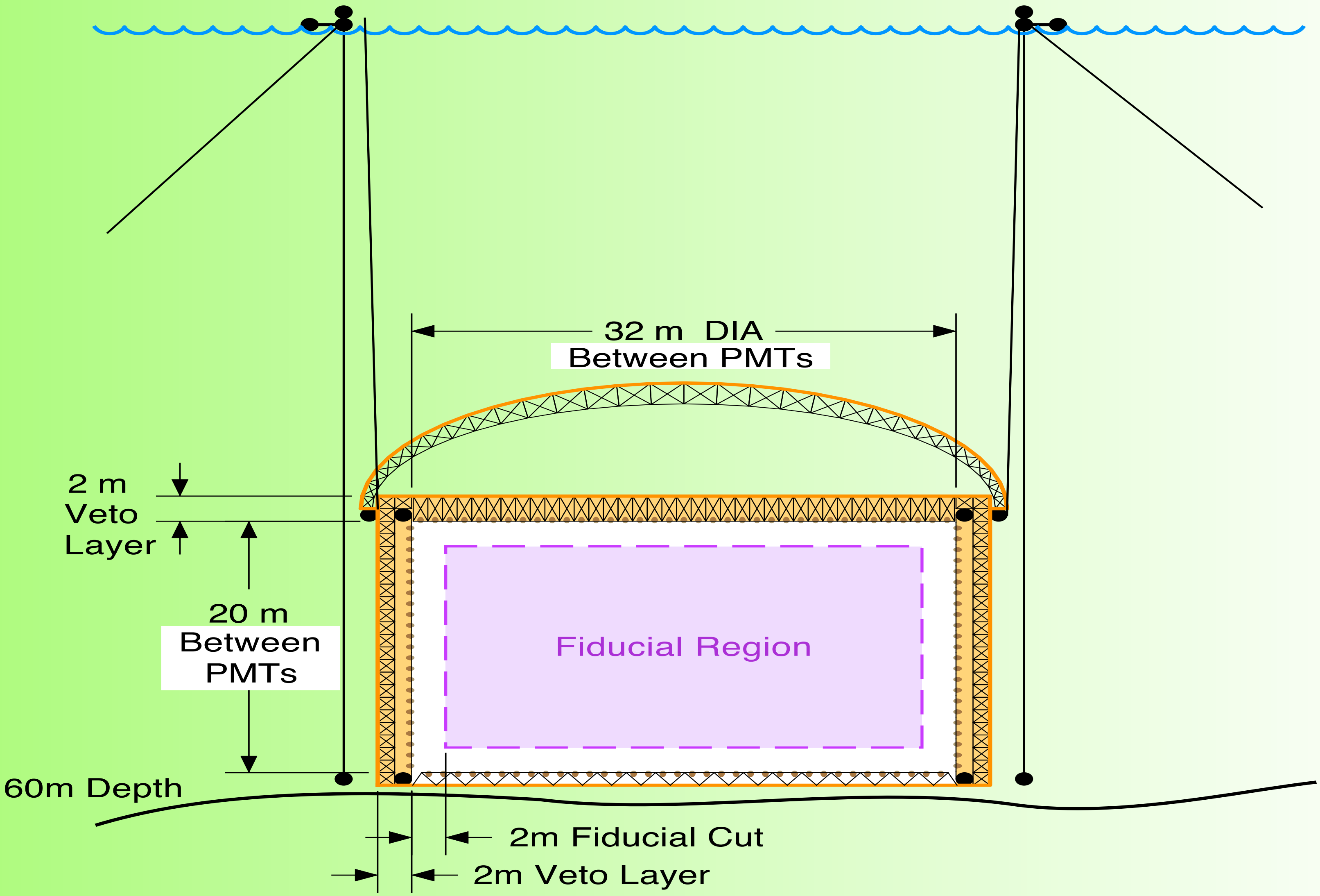


Inner components





WBS 1.11 : Integration and deployment



The nuts and bolts : this coming year

- Design and build 5m (h) x 3m (r) mechanical structure
- Deliver ex-NOVA container for DAQ and Purification plant
- Deploy “small” liner
  - Roofing company will “construct” it
  - Test robustness, light tightness, winter
- Layout pipe work and cables
- Deploy 5 IceCube DOMs plus readout with ad-hoc fixtures
- Incorporate GPS timing: look for evidence of beam pulses
- Build small (subpart) purification plant
  - Understand necessity of purification
- Demonstrate Ice Defense over winter
- Use Soudan surface building to stage equipment
- Deliver full CHIPS-10 technical design for full technical review

WBS 1.5.2: Mechanical Structure

- Mechanical Structure will be engineered at PSL
  - This work has started, contract signed, funded by U.Minn
  - Engineering drawings will go to W&M to be turned into full design drawings for industrial production of components
  - Components will be delivered to Soudan for assembly
- Part of this will impact the CHIPS-10 design engineering
  - Structure will be an extrapolation of that needed for CHIPS-10
  - Internal PMT Panels will be designed at U.Cincinatti to attach to CHIPS-10 structure

Next: LAPPD for Neutrinos

- Micro-channel plate photosensor in 8” x 8” tiles arranged in 24” x 32” super-module

- 100 psec time resolution / 1 cm spacial resolution

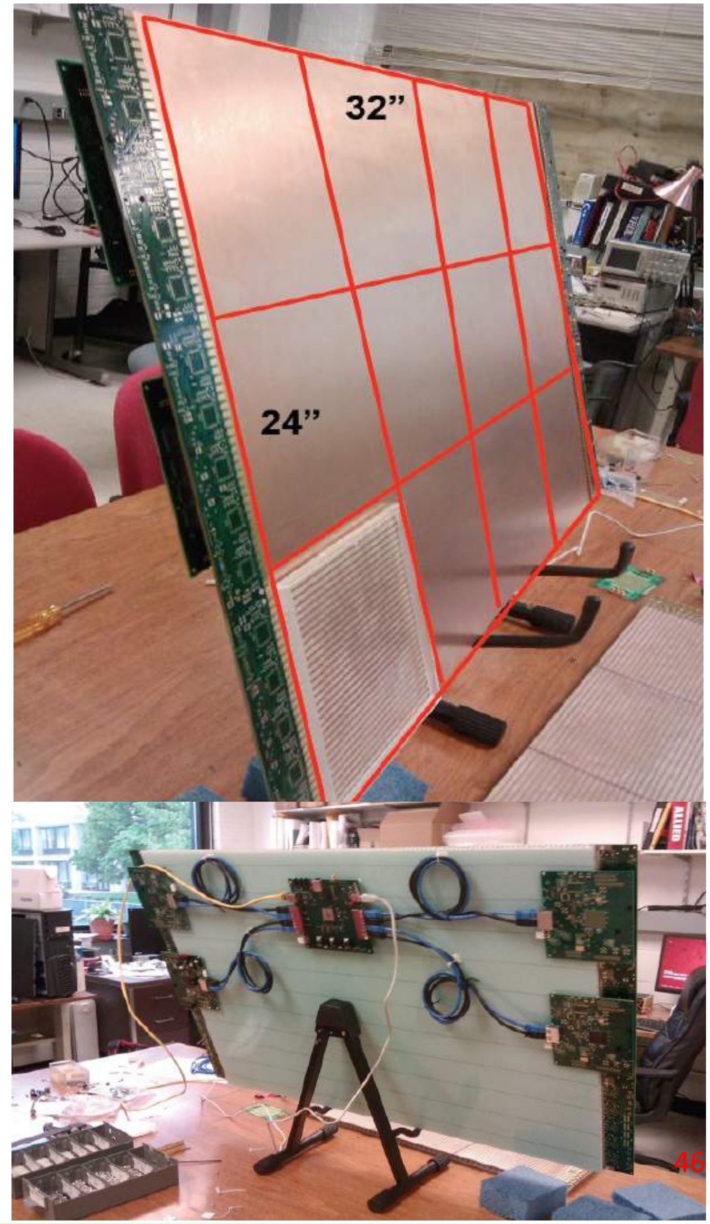
- Channel count optimized to large area/ desired granularity

- Integrated double-sided readout

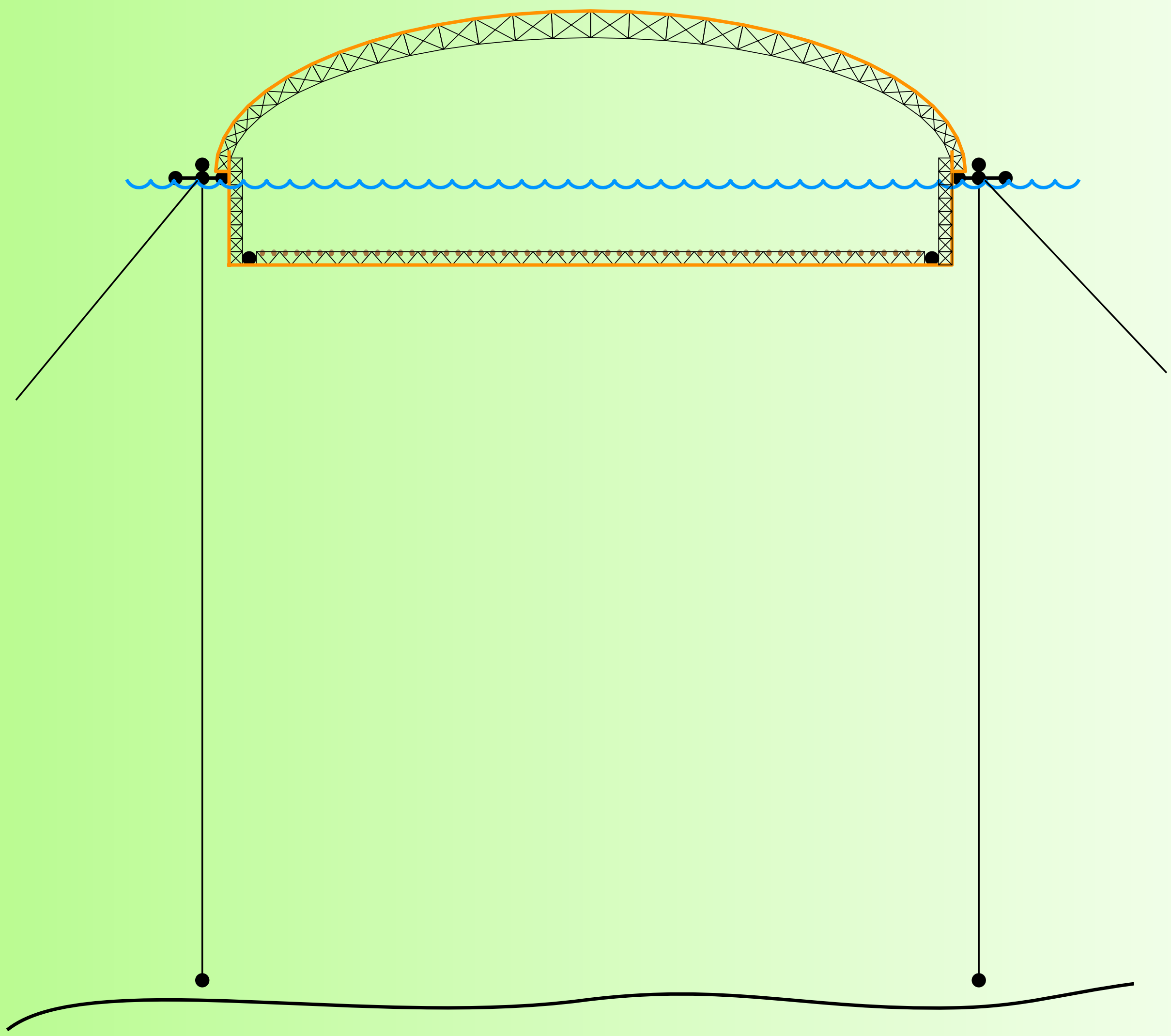
- Scaled high QE photocathode

- Large area flat panel provides robust construction. Low internal volume and use of known glass.

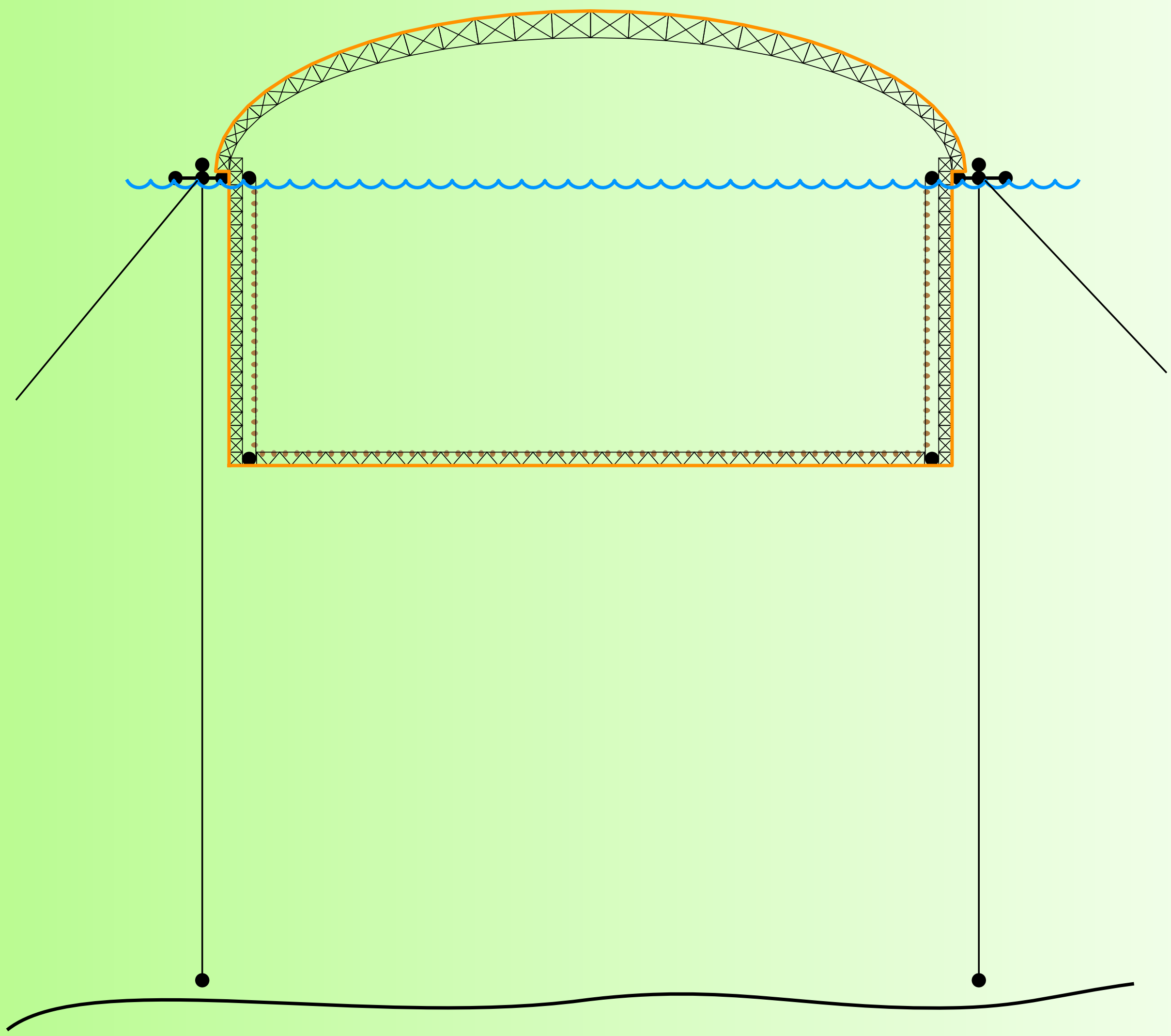
- No magnetic susceptibility



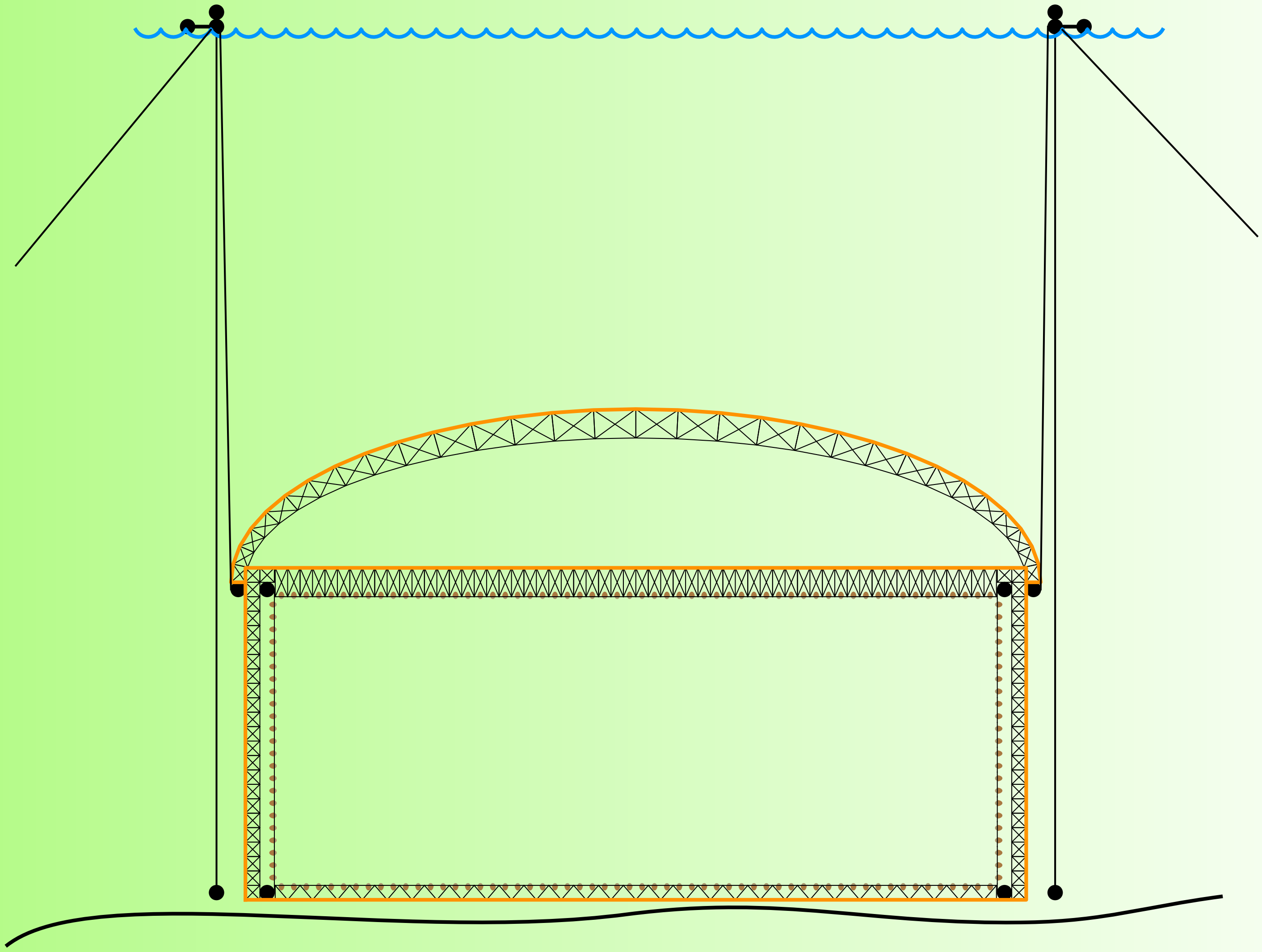
WBS 1.11 : Integration and deployment



WBS 1.11 : Integration and deployment

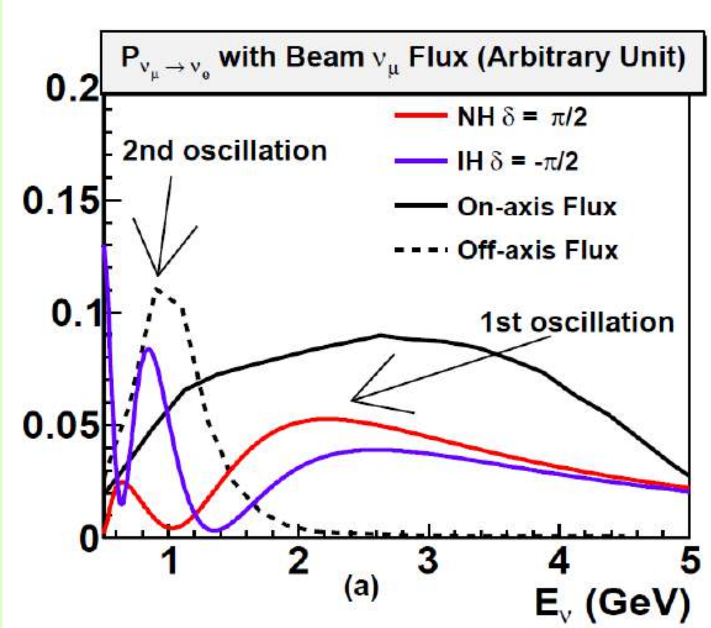


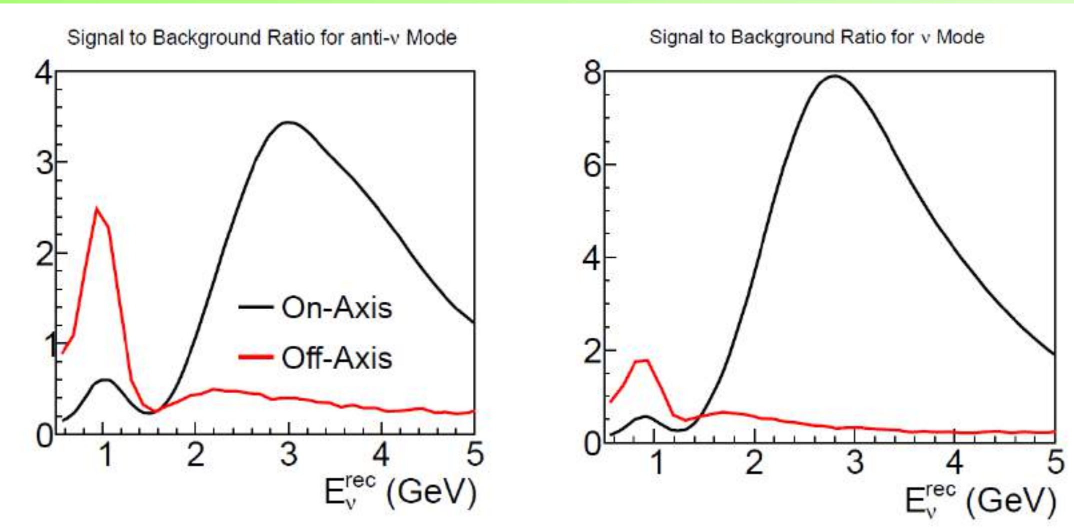
WBS 1.11 : Integration and deployment



Pros of 2^{nd} detector in LBNE

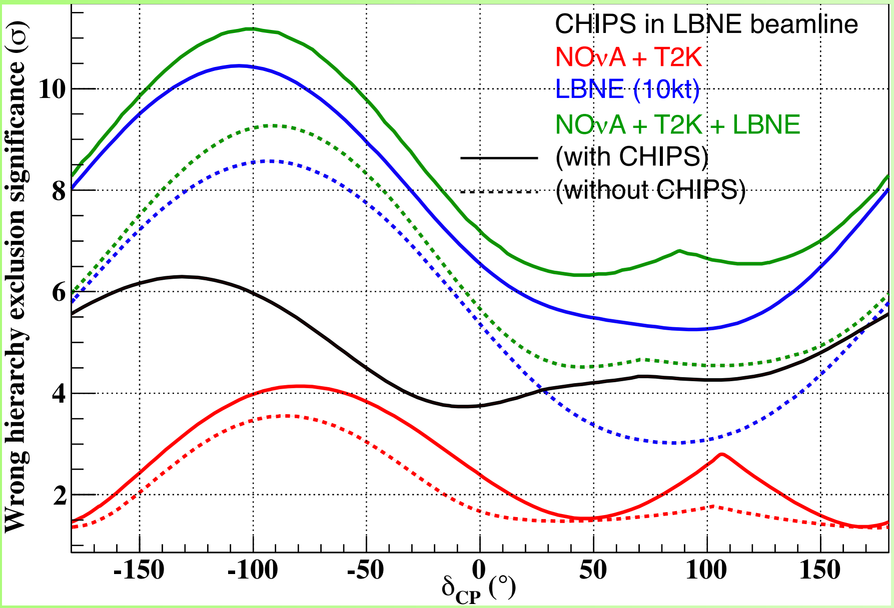
- 2^{nd} oscillation maximum located around 0.8 GeV
  - Large quasi-elastic x-section
  - Suitable for water Cerenkov detector
    - High efficiency for QE events

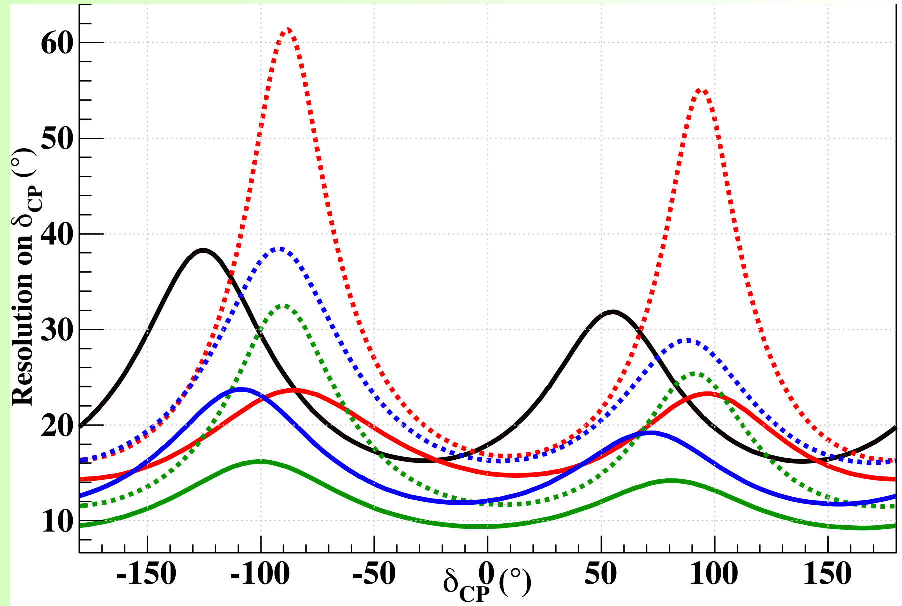




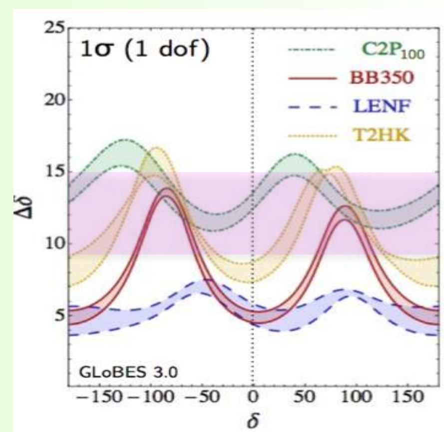
Better signal to noise ratio at 2^{nd} oscillation maximum (WC @ off-axis vs. LAr @ on-axis)

CHIPS



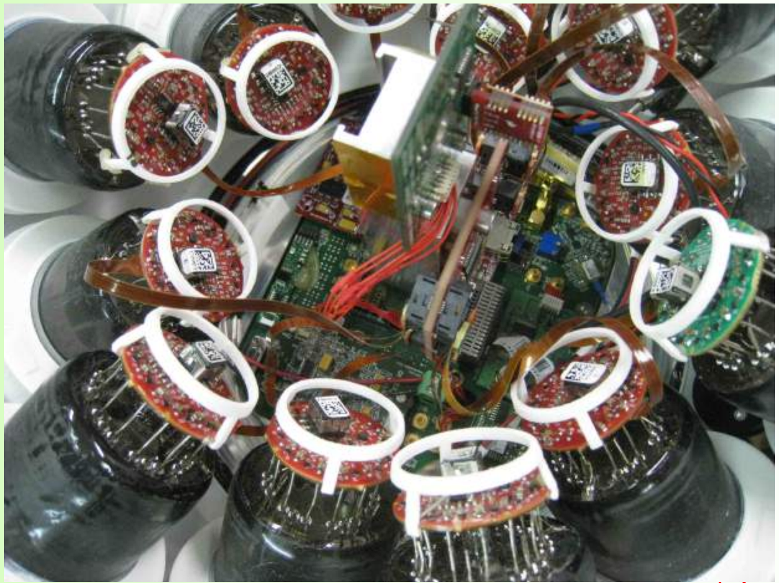


- CHIPS can make very big inroads into δcp
- Combination of on and off-axis gives good complementarity with NOVA
- LBNE could build SUBSTANTIALLY on CHIPS

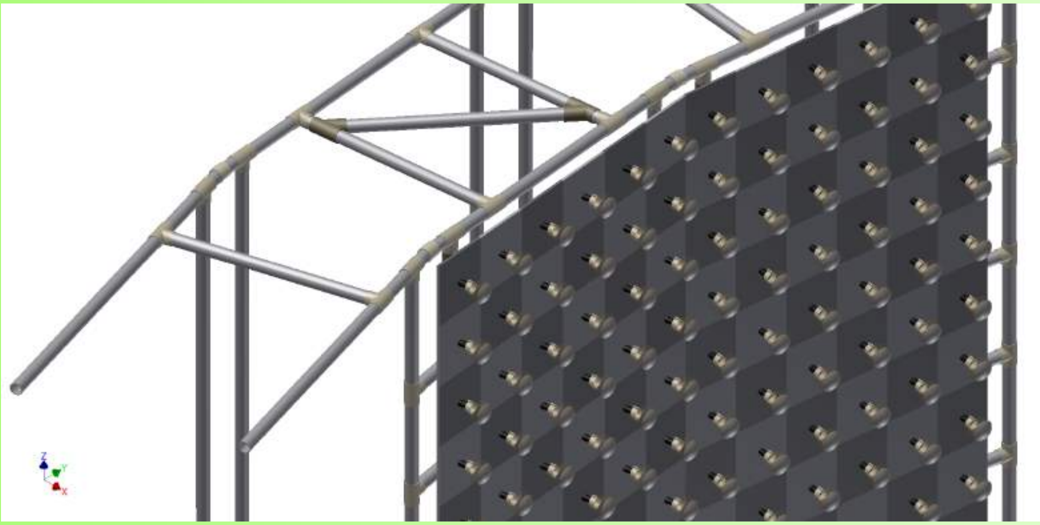


KM3NeT optical modules

- 31 PMTs of 3in diameter :
  - About the same cost as 11” (per unit photocathode area)
  - Much more competition for these tubes (medical industry)
- Mounted in a structure produced by a 3D printer
- Low-power Cockroft-Walton HV generator
- PMT signals processed locally using a specially developed ASIC and FPGAs.
- Time-over-threshold instead of waveform digitization
- Very thick glass DOM would be replaced with thinner acryllic
  - Two wires (power)
  - Two optical fibers
- The PMT-base developed at Nikhef, the central logic board (CLB) at Genova (board layout) and Nikhef (fpga firmware) and Saclay contibuted CLB prototypes.

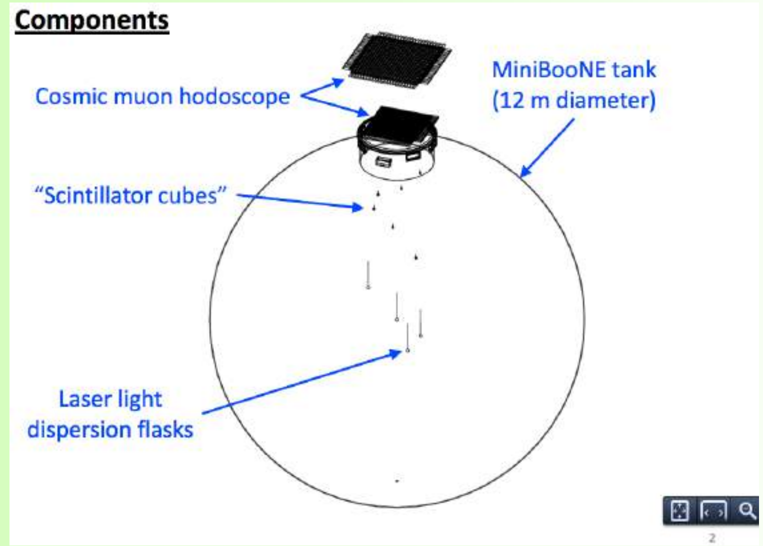


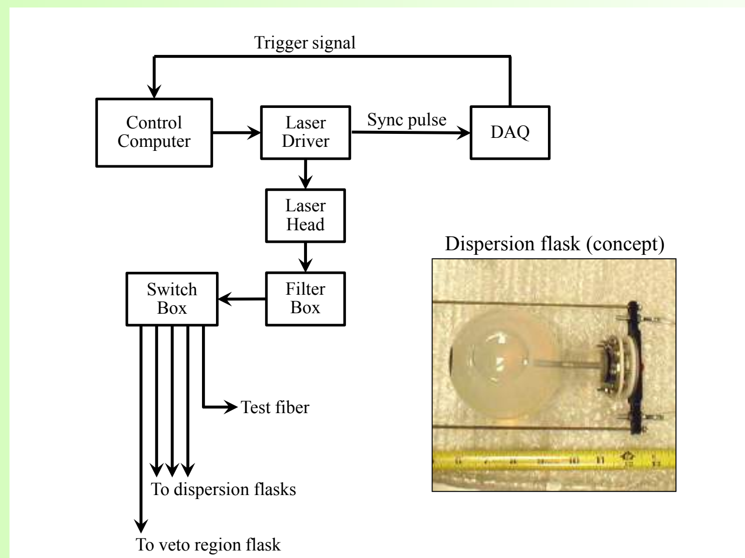
WBS 1.5 : Vessel



WBS 1.8: Calibration

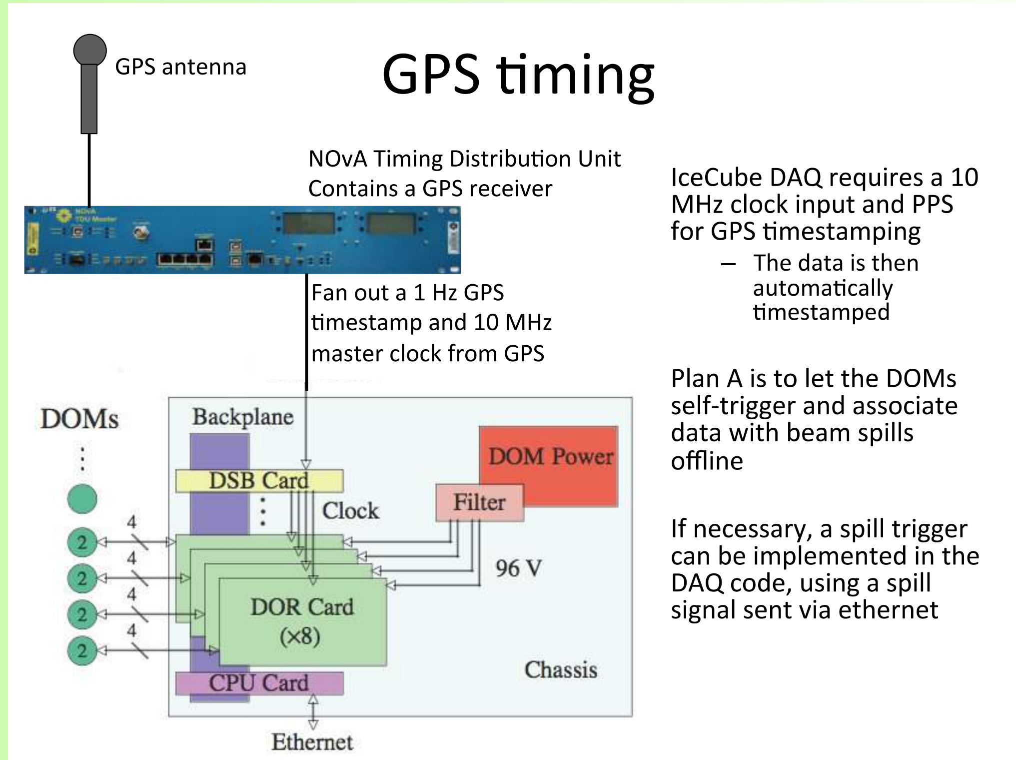
- Baseline design based on some MiniBOONE functionality : timing and light calibration
- Light "flasks" deliver led light into the middle of the volume
- In first year, led flashers on IceCube DOMS will be used to monitor attenuation length, timing etc
- KM3Net design also has LED flashers on board
- Need to understand whether on-PMT flashers, or MiniBOONE approach is easier/cheaper
- Expertise at CalTech and ISU will use LED flashers this year to understand how best to go about it



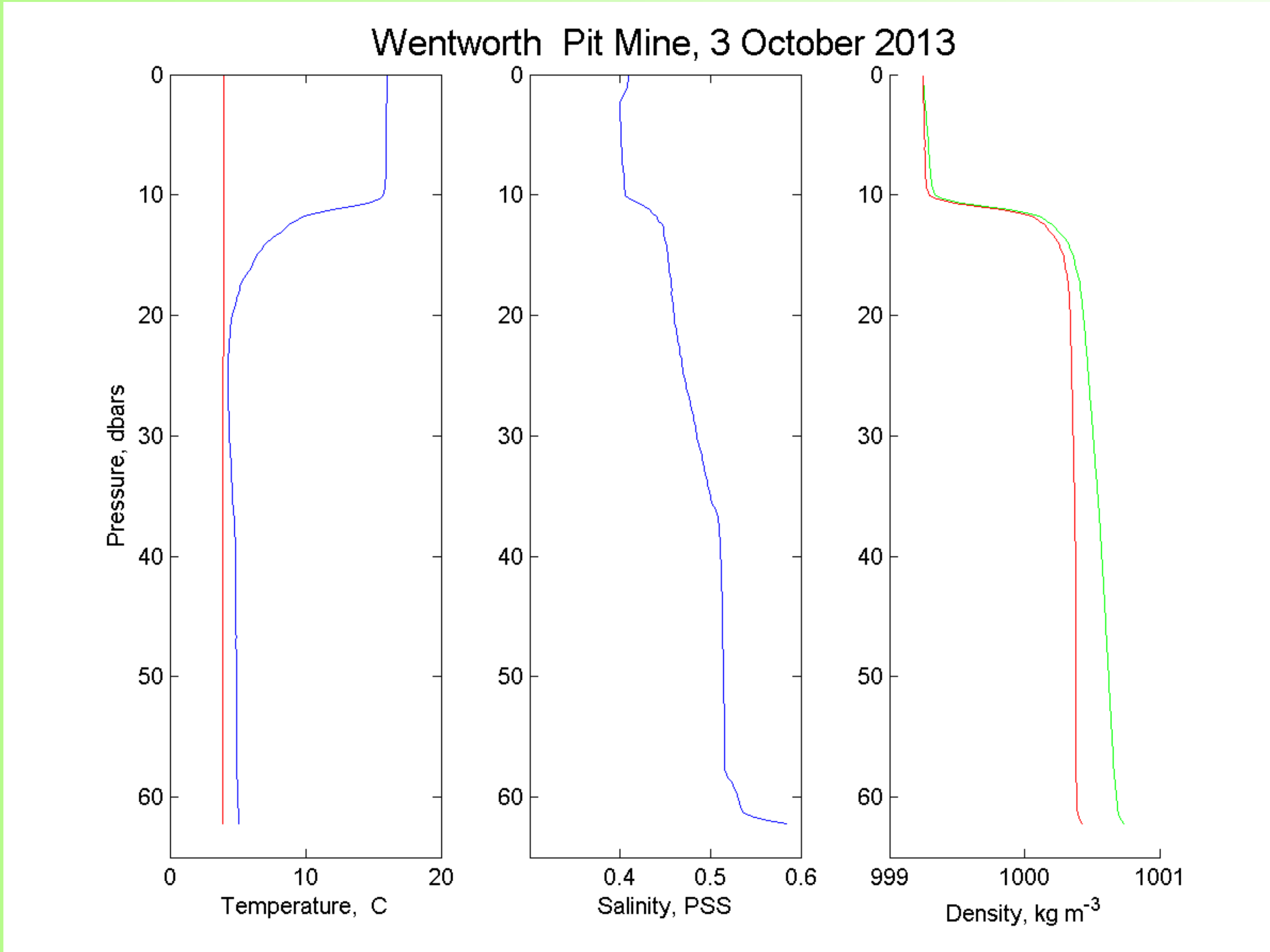


WBS 1.9: DAQ System, 1.10 HV

- CHIPS-M will use borrowed DAQ system from Ice Cube
  - GPS will be used to get spill signal into the data stream
  - Development needed will be carried out by UK
  - Very useful experience will be gained in its use, as likely it will be similar to the next prototype (CHIPS-10) system

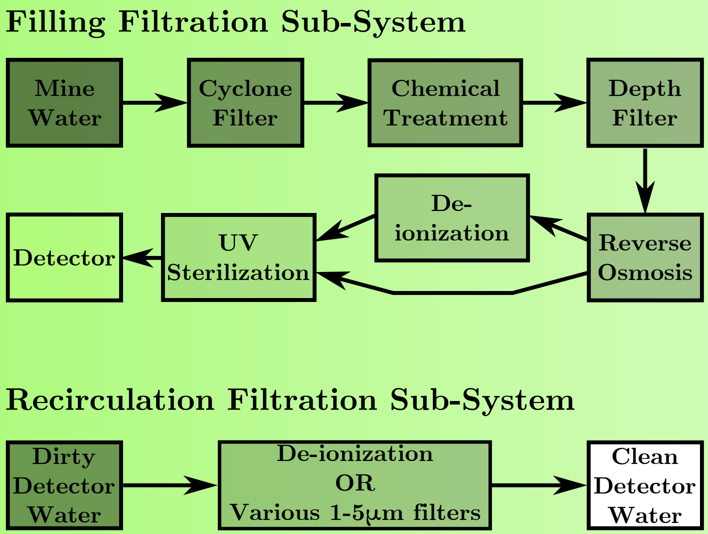


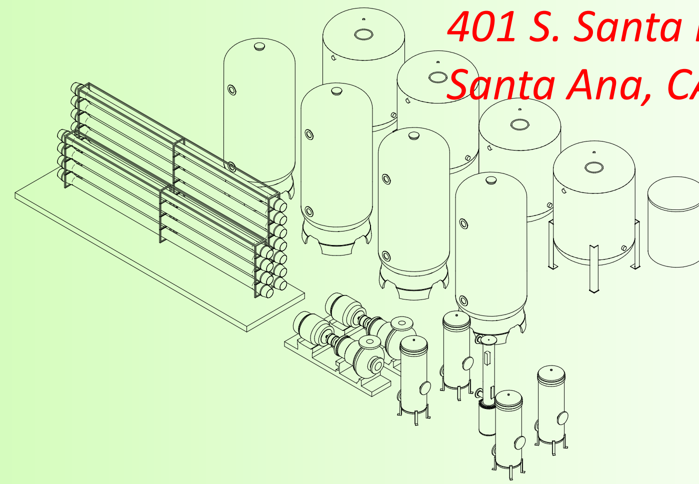
- We will likely use on-board CW power with control electronics incorporated inside the DAQ system
- Cables will likely be all that is left of a standalone HV system which will be combined with signal readout.
- Copper is likely most robust option given weather extremes at the pit (rather than optical, but TBD)



Recording probe results at the anchor site.
Note the water temperature change at 10m

WBS 1.6: Purification system





Roy E. Hall
South Coast Water
401 S. Santa Fe
Santa Ana, CA.

- Cost of small CHIPS-M system is $25k
- Cost of purification system is $800k for CHIPS-10
- On deploying doppler shift instrument, water much cleaner than expected
  - Previous measurement was a limit based on limited apparatus
  - POSSIBLE reduction in cost/capability allowable in case that natural water is clearer than expected
- This will be re-visited when ice melts in the spring.
- For this year, we will use minimal system which moves and filters water to understand layout of pipes and pipe joins to the liner